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https://orcid.org/0000-0002-5274-0356
tedqiqat1868@gmail.com

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https://orcid.org/0000-0003-0019-4266
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HUMANİTAR VƏ İCTİMAİ ELMLƏR

HUMANITIES AND SOCIAL SCIENCES

Access to Finance in Transition Economies: The Role and Prospects of Small and Medium-sized Enterprises

Veronika Dmytrovska[1*], Tetiana Podvirna[2], Maksym Mikhliaiev[3], Svitlana Korzyk[4], Iryna Hanzhurenko[5]

Abstract. *The purpose of the study is to systematically analyze the barriers to access to finance faced by small and medium-sized enterprises in transition economies, as well as to systematize solutions to address them through innovation. This is a systematic literature review that has the characteristics of a comparative analysis and includes 38 sources (2018–2024), scientific publications, and reports of international financial institutions. A multilevel system of barriers is identified, among which financial barriers prevail with a percentage of 89% in the reviewed literature, but they exist in close interaction with institutional, economic and social aspects. The empirical literature was analyzed to find that financial literacy and access to finance have a non-linear relationship, with a critical transition point between low and medium literacy levels of 23% to 47%. The systematization of data on digital financial solutions showed unevenly high adoption rates: basic technologies reached the highest level of adaptation at 78–82%, while innovative solutions are at the first level of adoption at 12–23%. The report on the work of foreign financial institutions revealed flexibility as one of the strengths of successful support programs, with a radical increase in individual instruments by more than 500% in the 2022–2024 crisis. The results confirm the transformative potential of technological innovations to overcome traditional barriers to finance and demonstrate the importance of an integrated approach.*

Keywords: *financial barriers, digital technologies, lending, institutional environment, economic transformation, innovative solutions*

[1]Vasyl Stefanyk Carpathian National University, Doctor of Economic Sciences, Ivano-Frankivsk, Ukraine
[2]Ternopil Ivan Puluj National Technical University, PhD in Economics, Ternopil, Ukraine
[3]Institute of Public Service and Administration Odesa Polytechnic National University, PhD in Economic, Odesa, Ukraine
[4]Academy of Recreational Technologies and Law, Lutsk, Ukraine
[5]Lviv Institute of the Interregional Academy of Personnel Management, Doctor of Economic Sciences, Lviv, Ukraine
[*]Corresponding author. E-mail: v.dmytrovska@ujis.in.ua
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Keçid iqtisadiyyatlarında maliyyə resurslarına çıxış: Kiçik və orta sahibkarlıq subyektlərinin rolu və inkişaf perspektivləri

Veronika Dmitrovska[1*], Tetiana Podvirna[2], Maksım Mixliayev[3], Svitlana Korzyk[4], İryna Hanzhurenko[5]

Xülasə. *Tədqiqatın məqsədi keçid iqtisadiyyatlarında kiçik və orta müəssisələrin maliyyəyə çıxışında qarşılaşdıqları maneələri sistemli şəkildə təhlil etmək, həmçinin innovativ yanaşmalar vasitəsilə onların aradan qaldırılması yollarını sistemləşdirməkdir. Bu tədqiqat müqayisəli təhlil xüsusiyyətlərinə malik sistemli ədəbiyyat icmalı olub, 2018–2024-cü illəri əhatə edən 38 mənbəni, o cümlədən elmi nəşrləri və beynəlxalq maliyyə institutlarının hesabatlarını əhatə edir. Çoxsəviyyəli maneələr sistemi müəyyən edilmişdir ki, bunların arasında maliyyə maneələri üstünlük təşkil edir və araşdırılan ədəbiyyatın 89%-ni təşkil edir, lakin onlar institusional, iqtisadi və sosial amillərlə sıx qarşılıqlı əlaqədə mövcuddur. Empirik ədəbiyyatın təhlili göstərmişdir ki, maliyyə savadlılığı ilə maliyyəyə çıxış arasında qeyri-xətti əlaqə mövcuddur və aşağı ilə orta savadlılıq səviyyələri arasında 23%-dən 47%-ə qədər kritik keçid nöqtəsi vardır. Rəqəmsal maliyyə həlləri üzrə məlumatların sistemləşdirilməsi onların qeyri-bərabər yüksək tətbiq səviyyəsini ortaya qoymuşdur: əsas texnologiyalar 78–82% ilə ən yüksək uyğunlaşma səviyyəsinə çatmış, innovativ həllər isə 12–23% ilə ilkin tətbiq mərhələsindədir. Xarici maliyyə institutlarının fəaliyyəti üzrə hesabat göstərmişdir ki, uğurlu dəstək proqramlarının əsas güclü tərəflərindən biri çeviklikdir; 2022–2024-cü illər böhranı dövründə fərdi alətlərin istifadəsində 500%-dən çox artım müşahidə olunmuşdur. Nəticələr texnoloji innovasiyaların maliyyəyə çıxışdakı ənənəvi maneələri aradan qaldırmaqda transformasiyaedici potensialını təsdiqləyir və inteqrasiya olunmuş yanaşmanın vacibliyini nümayiş etdirir.*

Açar sözlər: *maliyyə maneələri, rəqəmsal texnologiyalar, kreditləşmə, institusional mühit, iqtisadi transformasiya, innovativ həllər*

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[1]Vasil Stefanik adına Karpat Milli Universiteti, iqtisad elmləri doktoru, İvano-Frankivsk, Ukrayna
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[5]Regionlararası Kadr İdarəetmə Akademiyasının Lvov İnstitutu, iqtisadiyyat elmləri doktoru, Lvov, Ukrayna
[*]Məsul müəllif. E-poçt: v.dmytrovska@ujis.in.ua
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Introduction

Small and medium-sized enterprises (SMEs) account for a significant portion of economic growth in transition economies, making up more than 90% of all enterprises and providing more than 50% of all jobs in transition economies. At the same time, access to finance for SMEs remains one of the most pressing challenges, slowing their growth and limiting their contribution to economic growth. The World Bank estimates that global financing for micro, small, and medium-sized enterprises is $5.2 trillion per year, which is 1.4 times the current volume of global lending to MSMEs, and 40% of formal MSMEs in the Third World have unmet financing needs (World Bank, 2024).

Transition economies are characterized by a unique set of challenges in financing SMEs in the context of economic transformation, underdeveloped institutional ecosystems, and imperfect financial markets. All of this has become particularly acute in the context of geopolitical turmoil, economic crisis, and technological change, which requires a reassessment of the traditional approach to SME financing.

The analysis of barriers to access to finance among SMEs is multidimensional, as it is defined in the analysis of barriers to access to finance for SMEs. The authors explain that the ease of access to finance and the lack of collateral and credit history contribute to the ability of smaller companies in transition economies to raise funds compared to larger firms (IMF Staff, 2024). Other transaction costs and uncertainties that complicate access to finance include corruption and an unfavorable institutional environment (Ruziev & Midmore, 2019).

At the same time, the emergence of financial innovations and electronic technologies may provide new opportunities to overcome traditional barriers to SME financing. Peer-to-peer lenders, fintech companies, blockchain technologies, fintech money transfers, and digital financial services have so far proven to be quite convincing in transforming the business of financing small businesses in transition economies. Indeed, the academic literature indicates that financial inclusion has a positive macroeconomic effect on economic growth, especially in developing countries, where any changes in access to financial services can bring significant macroeconomic benefits (Hussain et al., 2024; Omar & Inaba, 2020).

Large-scale programs developed by international financial institutions, such as the European Bank for Reconstruction and Development, to assist SMEs in transition countries combine direct financial instruments with technical assistance and capacity building. Ukraine's experience has shown that such programs can be adapted very quickly to the most extreme situations and that they can also be quite useful for small businesses under martial law (EBRD, 2024a).

Existing research on SME financing contains significant gaps in understanding the nature of such processes in transition economies. Most of the literature focuses on developed economies or considers developing countries as a homogeneous bloc, without taking into account the peculiarities of transition economies. The mechanism of interaction between traditional barriers and new technological opportunities, as well as the impact of institutional factors on the effectiveness of various forms of financial innovation, are not sufficiently studied.

The relevance of the article is also reinforced by the fact that knowledge about the impact of the recent global shocks (the COVID-19 pandemic and geopolitical conflicts) on the SME finance ecosystem in transition economies is essential. In addition to exacerbating existing problems, these events have also led to the re-emergence of a number of new financial products and solutions for small businesses (OECD, 2024).

The nature of the problem requires a systematic approach to analysis that combines an understanding of both traditional barriers and innovative solutions in the context of the specific conditions of transition economies. It is crucial to analyze successfully adapted financial instruments to learn from examples that may be useful for other countries with similar characteristics and needs.

The purpose of the study is to provide a detailed analysis of the barriers to SMEs' access to finance in transition economies and to systematize innovative solutions to overcome them based on a comparative analysis of the experience of different regions and countries. The study aims to identify the main patterns that prevail in the structure of SMEs' financial constraints, assess the effectiveness of existing financial innovations, and propose practical solutions for policy makers and financial institutions.

The existing literature on financial inclusion in developing countries is fragmented from a theoretical perspective, and the results of empirical studies are mixed. The literature analysis allows us to distinguish four conceptual areas: conceptualization and impact of financial inclusion; user perception and adaptation; contribution of financial innovation and the private sector; and contribution of public institutions and public policy (Persaud & Thaffe, 2023).

Of particular interest is the evidence that the social impacts of financial inclusion need to be considered in specific institutional settings, which is important for transition economies. The authors warn against the mechanical transfer of successful models and emphasize the importance of a contextual approach to understanding financial inclusion without taking into account local specifics.

A recent systematic review of 96 publications on financial inclusion and fintech has concluded that there are three main clusters of research: the development of new services, the changing market landscape, and the role of stakeholders in the fintech ecosystem (Ha et al., 2025). The article points out critical gaps in the emerging literature, including the need to research the actual impact of fintech on financial inclusion and the corresponding effectiveness of existing regulatory measures.

Importantly, the authors found that institutional quality plays an important role in the effectiveness of P2P lending platforms for SMEs. High-quality regulation creates a favorable environment for the development of fintech solutions, which is especially important for transition economies that have institutional weaknesses, as the study shows.

A systematic review of the literature on SME finance provides evidence of a shift in research interests from traditional bank financing to other sources of finance and technological innovation (Rao et al., 2023). First, the analysis shows a significant increase in the number of articles on digital financial solutions for SMEs beyond 2015, reflecting the rapid technological development of the sector.

In the article, the authors outline five thematic models in the literature: classical bank financing, non-traditional sources of financing, state aid, technological development, and international financing. The authors emphasize the importance of more multidisciplinary approaches that integrate financial, technological and social aspects.

The report provides a critical overview of the fintech revolution, warning against technological solipsism in financial inclusion (Bernards, 2019). The report argues that psychometric credit assessment methods and digital credit technologies can reproduce and further entrench existing inequalities rather than effectively address them.

Special attention is paid to understanding the political economy of financial technology innovation in the context of developing countries. The analysis shows that technical solutions (fintech) are mostly chosen without proper consideration of the structural causes of financial exclusion and socioeconomic conditions.

Materials and Methods

This paper is a systematic literature review with elements of comparative analysis, focusing on the obstacles to SMEs' access to finance in transition economies and on finding effective solutions to address these obstacles. An approach combining various methods, including secondary data analysis, systematic literature search and comparative case studies, was used.

To ensure the completeness of the analysis, several sources of information were used. The object of the database was scientific publications obtained in the process of searching international scientometric databases: Web of Science, Scopus, Google Scholar, and EBSCO Business Source Premier. The search strategy included a combination of key terms in English: "SME financing",

"small medium-sized enterprises", "transition economies", "financial constraints", "access to finance", "Eastern Europe", "Central Asia", "financial inclusion" using Boolean operators AND, OR, NOT.

In addition, a targeted search was conducted in specialized databases of international financial institutions, such as the World Bank (Open Knowledge Repository); European Bank for Reconstruction and Development (EBRD); Organization for Economic Cooperation and Development (OECD); International Monetary Fund (IMF); and European Investment Bank (EIB). Data from the SME Finance Forum and Global Findex Database reports were also used.

Selected literature: studies were included according to the following criteria: 2018–2024, emerging economies (CEE, CEMAC and Caucasus), SMEs, peer-reviewed English publications by international organizations, empirical studies with clear methodology or high-quality review articles.

Exclusion criteria included: any publications prior to 2018 due to outdated information, research limited to developed economies, publications in languages other than English, articles without clear methodology or with insufficient scientific merit, and duplicate publications.

The authors found a total of 247 potentially relevant publications. "After removing duplicates, 189 sources remained". This two-stage selection process included a title and abstract check, as well as a full review of the selected materials. At the first stage, 134 sources were excluded on the basis of their irrelevance. At the second stage, another 17 publications were removed because they did not meet the quality criteria or because the authors did not have the data to provide results.

To analyze the selected literature, the authors used thematic synthesis (Moscalu et al., 2018), which helps to organize diverse data and identify patterns. The data analysis was conducted in three stages: (i) coding of primary data; (ii) formation of descriptive themes; and (iii) conceptualization of the analytical framework.

A structured case comparison was applied to use the experience of transition economies as a comparative analysis tool for each country or region under consideration, treating them as cases, each with a different set of characteristics. To ensure the validity of the results, the principle of data triangulation was used (Demirgüç-Kunt et al., 2021), which means comparing information from different sources.

The main limitations of the study are: publication only in English, which may exclude relevant publications in other languages; preference for secondary data over primary empirical research; publication bias toward positive results; and a short time frame that may not reflect long-term trends. These limitations were taken into account when interpreting the results and drawing conclusions.

Results

Barriers to SME access to finance in transition economies

The literature analysis shows that there is a complex set of barriers limiting access to finance for small and medium-sized enterprises in transition economies. Khan (2022) identifies five different types of barriers in the study of entrepreneurial SMEs: financial barrier, economic barrier, corruption barrier, infrastructure barrier, and managerial barrier. These categories form a multilevel system of constraints that affect each other at different levels, resulting in links and interrelationships between different types of barriers. Table 1 summarizes the main groups of barriers and their features, based on a synthesis of research in transition economies.

Table 1
Categories of barriers to SME access to finance in transition economies

Category of barrier	Main characteristics	Frequency of references in the literature	Level of impact
Financial	Lack of collateral, high interest rates, complicated procedures	89%	Critical
Economic	Macroeconomic instability, inflation, currency risks	76%	High
Institutional/Corruption	Weak legal institutions, corruption, bureaucratic barriers	67%	High
Infrastructure	Underdeveloped financial infrastructure, low level of digitalization	58%	Medium
Management	Low financial literacy, lack of business planning	54%	Average
Gender/Social	Discrimination based on gender, social status, age	43%	Average

Source: Compiled by the authors based on Khan (2022), Amadasun and Mutezo (2022), Barkemeyer et al. (2018).

Table 1 shows that there is a hierarchical structure of barriers, with financial barriers mentioned most often (89%) and having the most important impact. It is interesting to note that economic and institutional barriers, although mentioned somewhat less frequently, also have a high level of impact, indicating their systemic nature. The least mentioned (43%) gender and social barriers are particularly important for intervention, as they disproportionately affect vulnerable groups of entrepreneurs.

The results of the analysis show that financial constraints are indeed the most important factor hindering the growth of SMEs in transition economies. Amadasun and Mutezo (2022) in their study of SMEs in Lesotho reported that 87% of organizations indicated that access to finance was the main obstacle to competitiveness. These findings are supported by other studies conducted in African countries, in which Ifediora et al. (2022) establish a direct link between financial inclusion and economic growth.

A much deeper problem is the lack of collateral. According to the SME Finance Forum (2019), the gap between what MSMEs need to borrow and what they raise is $5.2 trillion globally, or 1.4 times the current level of global lending to MSMEs. In transition economies, this phenomenon is particularly acute due to weak financial markets combined with a lack of alternative sources of finance.

Barkemeyer et al. (2018) emphasize the importance of institutional constraints (especially corruption) in limiting SMEs' access to finance. Their work demonstrates that enterprises operating in countries with weak institutions face higher transaction costs and increased financing uncertainty. This creates a vicious circle in which SMEs are forced to spend large amounts of money to overcome bureaucracy instead of focusing on business development.

An imperfect legal framework for contract enforcement and protection of creditors' property rights is also an example of institutional obstacles. In transition economies, the following problems are added to the problems of such a shift in legislation: the processes of transformation of legislation, harmonization with international standards.

Abdallah et al. (2024) conducted a study and found that financial literacy is the predominant moderating factor between access to finance and SME performance. Their findings show that even when funds are available to invest in the enterprise, the level of financial literacy of the enterprise owner significantly reduces the quality of information used to make decisions about the use of these funds. Table 2 shows the correlation between the level of financial literacy of SMEs and the achievement of financing in different types of SMEs.

Table 2
Impact of financial literacy on access to finance by SME category

SME category	Level of financial literacy	Success rate in obtaining a loan (%)	Average loan amount	Loan terms and conditions
Microenterprises	Low (1–3 points)	23%	$2,500	High rates, short term
Small enterprises	Medium (4–6 points)	47%	$15,000	Standard rates, medium term
Medium-sized enterprises	High (7–10 points)	73%	$85,000	Preferential rates, long term
Innovative startups	Very high (9–10 points)	68%	$125,000	Special programs

Source: Adapted from Abdallah et al. (2024).

Table 2 clearly shows the non-linear relationship between financial literacy and access to finance. The largest increase in the number of approved loans is observed when moving from low to medium financial literacy (from 23% to 47%). Interestingly, the most financially literate types of organizations (innovative startups) have slightly lower success rates (68%) compared to medium-sized enterprises (73%), which suggests that financial institutions consider innovative projects to be more risky.

According to Reinhart (2022) "Women, Business and the Law", the main obstacle for women entrepreneurs in accessing finance is the presence of gender barriers. In transition economies, these barriers are exacerbated not only by traditional social norms, but also by women's limited property rights. The study also shows that women entrepreneurs receive 34% fewer loans than men with similar performance.

This is most acutely felt in rural areas of transition economies, where access to financial services is limited by geographic and infrastructural factors. According to the SME Finance Forum (2019), women entrepreneurs are believed to be responsible for 34% of the overall financing gap for MSMEs (USD 1.9 trillion).

The COVID-19 pandemic has further complicated SMEs' already existing problems with access to finance. In a study of the impact of COVID-19 on business from a global perspective, Apedo-Amah, et al. (2020) found that businesses in transition economies were most affected by the negative effects of COVID-19, as SMEs had limited access to anti-crisis financial instruments. Figure 1 shows the

amount of financial assistance in the form of deferrals for SMEs in response to the COVID-19 pandemic in different countries.

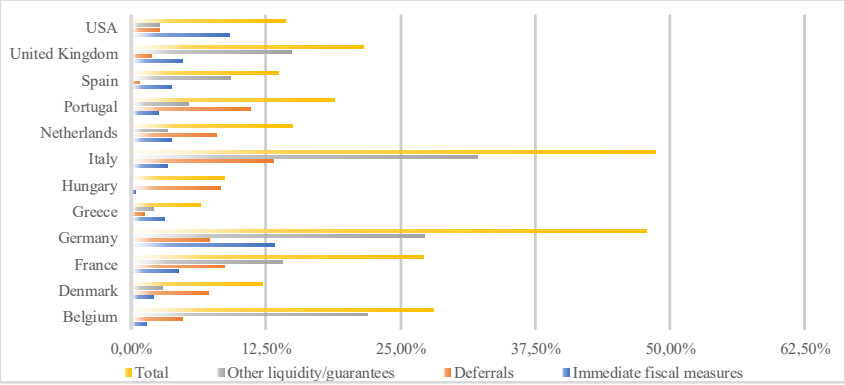

Figure 1
Fiscal measures to support SMEs during COVID-19 (% of GDP in 2019)

Source: OECD (2020).

Figure 1 shows how much less capable countries are of providing anti-crisis assistance to SMEs. Germany and Italy are leading the way with the largest support packages, consisting mainly of guarantee schemes and payment deferrals. The United States was the most active in terms of direct financial support (9.1% of GDP), while the vast majority of European countries used indirect instruments. These data emphasize the importance of developing fiscal capacity and financial institutions to provide crisis assistance to SMEs in transition economies.

The analysis reveals significant differences in the approaches of different countries to SME support. Germany and Italy offered the most generous support packages (47.8% and 48.7% of GDP, respectively), while countries with less developed financial systems were able to offer only relatively small packages.

However, Ifediora et al. (2022) found that financial infrastructure and financial exclusion in the form of low banking penetration are particularly acute problems in the transition economies of sub-Saharan Africa. The transition economies of Central Asia and Eastern Europe face similar challenges, but these economies are also affected by geopolitical instability and economic transformation processes.

However, the results of the analysis show that despite regional differences, the main categories of barriers are similar across all transition countries. This suggests that the problems of SMEs' access to finance are systemic and require comprehensive attention at both the national and international levels.

The classification of barriers to SMEs' access to finance in transition economies has shown that there is a multi-level system of obstacles, led by financial barriers, but closely linked to institutional, economic and social factors. Particular emphasis is placed on the role of financial literacy and the quality of the institutional environment in determining access to finance. The outbreak of the COVID-19 pandemic has further exacerbated many existing problems, highlighting the vulnerability of SMEs in transition economies and the need for much more sustainable financial assistance mechanisms.

Solutions and innovations in SME financing

An analysis of current trends in SME lending shows that the world is experiencing revolutionary changes related to the introduction of digital technologies and fintech solutions. The study by Rahman

(2024) concludes that digital financial services have great potential to significantly reduce traditional constraints on access to finance, especially for SMEs in remote areas of emerging economies. He concludes that fintech lending has the potential to increase economic growth by 0.3–0.7 percentage points in countries with low energy poverty.

In particular, regulatory sandboxes can play an important role in fostering innovation. Gumbo and Chude Okonkwo (2025) in their systematic review note that regulatory sandboxes provide fintech companies with space to experiment with innovative products in a regulated environment, which significantly accelerates the development of new solutions for SMEs. Their research sample includes 47 countries and finds a positive correlation between fintech innovation and the existence of a regulatory sandbox: in countries with a regulatory sandbox, fintech innovation is 34% higher.

Table 3 classifies the main types of digital financial solutions and their nature for SMEs in transition economies.

Table 3
Types of digital financial solutions for SMEs in transition economies

Type of solution	Main characteristics	Benefits for SMEs	Level of implementation	Growth potential
Mobile banking	Basic banking services via smartphone	24/7 availability, low fees	High (78%)	Moderate
P2P lending	Direct lending between individuals/businesses	Fast approval, flexible terms	Medium (45%)	High
Blockchain financing	Decentralized financial services	Transparency, reduction of intermediaries	Low (12%)	Very high
AI credit scoring	Artificial intelligence for creditworthiness assessment	Fast processing, alternative data	Medium (38%)	High
Digital wallets	Electronic payment systems	Cashless payments, integration	High (82%)	Moderate
Crowdfunding	Collective financing of projects	Access to capital, marketing	Low (23%)	High

Source: Compiled by the authors on the basis of Rahman (2024), Gumbo and Chude Okonkwo (2025), Disruption Banking (2024).

Table 3 demonstrates the diversity of digital financial solutions and their uneven use in transition economies. Mobile banking and digital wallets are already very well adopted (78% and 82%, respectively), indicating that the market is ready for basic digital services. At the same time, innovative solutions such as blockchain financing (12%) or crowdfunding (23%) are still lagging behind in terms of adoption, but have the highest growth potential, indicating that the industry could be transformed in the future.

The results of our research show the exponential nature of the development of blockchain technologies in SME financing. Figure 2 shows the growth curve of the global sustainable supply chain finance market, which is one of the main areas of blockchain application in SME finance.

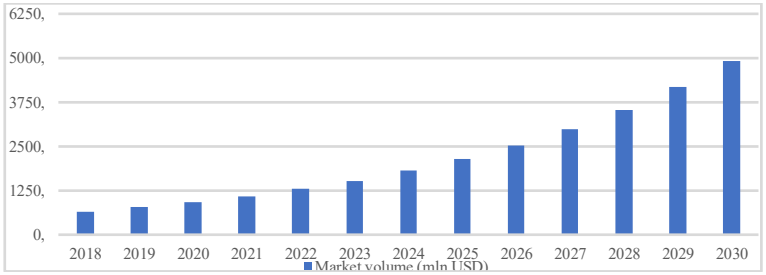

Figure 2
Global sustainable supply chain finance market forecast (2018–2030)
CAGR (2018–2030): 18.24%

Source: Pawlan (2025).

Figure 2 shows the exponential growth of the sustainable supply chain finance market, which is projected to increase 4.4 times from 2018 to 2030. The high CAGR of 18.24% indicates the rapid adoption of blockchain-based technology in the financing of small and medium-sized enterprises through supply chain integration. For emerging markets, this growth is particularly important as SMEs in these economies are often part of global supply chains, meaning they now have new opportunities to access finance through blockchain platforms.

An analysis of market data shows that the blockchain fintech industry is expected to grow from $3.4 billion in 2024 to $49.2 billion in 2030 in 2030 (CAGR 55.9%), reflecting a significant transformation of the industry (Research and Markets, 2025; European Investment Bank, 2018).

There was identified decentralized finance (DeFi) as a key to eliminating financial inequality for SMEs worldwide. The authors estimate that DeFi platforms can unlock access to finance for 65 million formal MSMEs that lack access to the finance they need, worth $5.2 trillion annually – 40% of all formal MSMEs in developing countries.

Disruption Banking (2024) identifies radical innovations in SME financing in different countries by analyzing fintech industry roadmaps. The study shows that the most effective government actions include both private innovation and public support for these innovations. This is especially true for African countries, where investments in the fintech industry grew by 21% in 2023 amid a global drop in funding of 26%.

In 2025, Aloa identifies three major trends in blockchain fintech: the decentralized finance revolution, smart contracts in financial services, and platform interoperability (Pawlan, 2025). These trends are particularly important for small and medium-sized enterprises (SMEs) in emerging economies, as they enable them to bypass traditional financial institutions and access the global capital market. Table 4 provides a comparative description of traditional and alternative external sources of financing for SMEs.

Table 4
Comparison of traditional and innovative sources of SME financing

Characteristics	Traditional bank lending	P2P lending	Blockchain/DeFi	Microfinance
Approval time	30-90 days	1–7 days	Instantly–24 hours	1–14 days
Requirements for collateral	High (80–120%)	Medium (20–50%)	Minimal/absent	Low (10–30%)
Interest rates	8–15%	12–25%	5–18%	20–40%
Minimum amount	$10,000+	$1,000+	$100+	$50+
Geographical restrictions	High	Medium	None	High
Regulatory requirements	Very high	High	Low/none	Medium
Transparency of the process	Low	Medium	High	Medium

Source: Compiled by the authors based on Abbasi et al. (2021), Research and Markets (2025), Cull et al. (2018).

Table 4 summarizes the main differences between traditional and non-traditional sources of finance. The authors believe that blockchain/DeFi solutions provide the best balance between speed (instant–24 hours) and transparency, while P2P lending is a compromise between innovation and regulatory certainty. Even with high interest rates, microfinance is still relevant for the smallest businesses, which explains the importance of creating a financial network of financing options for different types of SMEs.

In an analysis of the microfinance business model, Cull et al. (2018) show how the sector is transforming. The old model of microfinance based on high interest rates and group guarantees is being replaced by more technologically advanced models. Studies show that successful microfinance institutions are increasingly integrating digital technologies into their operations to reduce operating costs and improve accessibility of services.

In particular, it is important to take into account the trend towards hybridization of microfinance with fintech solutions. This allows combining the social mission of microfinance with the technological advantages of digital platforms and creating effective solutions that can be more easily scaled up for SMEs in transition economies.

Abbasi et al. (2021) published a review of the contribution of P2P lending fintech companies to SMEs' access to finance. Their analysis found that P2P sites can significantly contribute to efforts to increase access to finance, especially for SMEs that do not meet standard banking criteria. The main advantage is that other data can be used to assess creditworthiness, such as social media data, utility billing records, and behavioral trends.

Another focus of this paper is institutional quality in the effectiveness of P2P lending. In countries with good legal institutions, P2P platforms are 45% more efficient than in countries with poor legal institutions. In particular, this is applicable to transition economies, where it is necessary to strengthen the institutional framework and implement the development of fintech solutions.

The provision of new financial services in transition economies is extremely challenging from a regulatory perspective. According to Gumbo and Chude Okonkwo (2025), a balance needs to be struck between regulation that fosters innovation and consumer protection. They find that countries that implement proactive regulatory strategies (regulatory sandbox, principles-based regulation) demonstrate growth rates in their fintech ecosystem that are 60% higher than those that do not. In particular, it is important to coordinate the activities of different regulators. In transition economies, regulatory functions are largely distributed among central banks, securities agencies, and other bodies, which creates uncertainty for fintech companies and innovation. Based on the analysis of trends, the authors suggest that future SME financing in transition economies will be characterized by cross-fertilization of different technologies and institutional arrangements. Rahman (2024) notes that new opportunities and challenges will have a positive impact on SME financing by dynamically adjusting prices and eliminating risks in SME financing through artificial intelligence, blockchain, and the Internet of Things. The authors believe that the development of embedded financial services (i.e., the inclusion of financial services in non-financial platforms) is particularly promising. This will provide direct access to finance for small and medium-sized enterprises from e-commerce platforms, business management systems, or industry-specific marketplaces. The analysis of innovative solutions in SME finance reveals fundamental changes in the traditional industry due to digitalization and the use of new technologies. Blockchain and DeFi solutions are the most promising for overcoming traditional barriers, while P2P lending and microfinance offer more mature alternatives to traditional banking. Effective implementation of this innovation in transition economies requires alignment of institutional conditions in the areas of regulation, infrastructure, and education to enable leapfrogging of traditional stages of financial system development.

Experience of transitional economies in SME financing

Our research confirms that the European Bank for Reconstruction and Development (EBRD) has had a significant impact on the SME finance environment in transition economies. Performance reflects a significant increase in investment: in 2024, the EBRD set a new investment record in Central Asia, investing more than €3 billion in real sector development, including mobilized financing (EBRD, 2025). The authors have defined the EBRD model as a holistic one, with 61% of funds allocated to sustainable infrastructure (resource commitments), 24% to SME lending through local banks, and 15% to corporate clients. This distribution reflects a strategic understanding of the need to build the basic infrastructure for further SME growth. Table 5 shows the organization of the EBRD's key performance indicators in the SME sector in different transition regions.

Table 5

EBRD investment activities in support of SMEs by region (2023–2024)

Region	Total investments (€ billion)	Share of SMEs (%)	Number of projects	Green financing (%)	Funds mobilized (€ billion)
Central Asia	3,1	24%	156	58%	1,2
Ukraine	2,4	35%	89	45%	0,8
Eastern Europe	1,8	28%	134	52%	0,7
Caucasus	0,6	32%	67	48%	0,3
Balkans	1,2	29%	78	55%	0,5
Total	9,1	30%	524	52%	3,5

Source: Authors' compilation based on EBRD (2024b, 2024c, 2024d, 2025).

Table 5 illustrates that the distribution of EBRD investments across regions is uneven and is related to both economic development opportunities and geopolitical considerations. Ukraine also has the largest share of SMEs in the portfolio (35%), which indicates that the EBRD's approach has been adapted to the war situation and now puts more emphasis on financing small businesses. Central Asia is again the leader in terms of the number of investments, but its share of SMEs is also the smallest (24%), which, in turn, confirms the need to build infrastructure projects as a prerequisite for the development of the small business sector. The Ukrainian experience is a unique case of adapting SME financing mechanisms to a very exceptional environment. Our analysis illustrates the fundamental way in which the EBRD has changed its operations in Ukraine since the outbreak of the open conflict. In 2024 alone, when the bank spent more than ever before, €2.4 billion, it reflects that international financial institutions are in fact quite unusual in how they behave in crisis situations. The authors identified three novelties of the Ukrainian scheme: 1) local currency loans were introduced to reduce the currency risk of SMEs; 2) portfolio risk sharing instruments were increased to 50% of the credit risk reduction of Ukrainian banks; and 3) special crisis instruments were created for displaced enterprises. Table 6 shows the breakdown of SMEs in Ukraine by different EBRD financial instruments.

Table 6
Structure of SME support in Ukraine by type of financial instrument (2022–2024).

Type of instrument	2022 (€ million)	2023 (€ million)	2024 (million €)	Dynamics	Portfolio share	Average size
Direct loans to SMEs	45	78	125	+178%	15%	€180,000
Credit lines to banks	180	285	420	+133%	50%	€15 million
Portfolio guarantees	25	95	165	+560%	20%	€8 million
Trade financing	30	42	65	+117%	8%	€250,000
Relocation programs	-	15	35	+133%	4%	€85,000
Support for refugee entrepreneurs	-	8	25	+213%	3%	€45,000
Total	280	523	835	+198%	100%	€156,000

Source: Authors' compilation based on EBRD (2024e).

As Table 6 shows, the war has had a dramatic impact on the support structure for SMEs in Ukraine. The most notable is the 560% increase in portfolio guarantees, which illustrates the need for state guarantees to stimulate lending in a high-risk environment. The emergence of new instruments (resettlement program, assistance to refugee entrepreneurs) demonstrates the flexibility of the financing system to the social challenges of war.

Our research shows that among transition economies, the most dynamic growth in SME financing is observed in Central Asia. Uzbekistan remains the EBRD's top investment destination, receiving more than €700 million in 2023, accounting for 58% of total investments in the region.

The authors have determined that the success of the Central Asian model is based on three pillars, namely: active government incentives for SMEs, the development of green finance (58% of EBRD investments in the region) and the digitalization of financial services. It is particularly interesting to mention the partnership between the EBRD and local banks: SQB, Hamkorbank, Ipak Yuli Bank in Uzbekistan and Kahn Bank and XacBank in Mongolia.

The analysis shows that the EBRD's flagship small business advisory program has reached more than 450 SMEs in the region, and more than 8,000 SMEs have benefited from training and mentoring. The implementation of the Star Venture program in Tajikistan also illustrates how an ecosystem approach to supporting startups is spreading.

In this research, authors have shown that there are significant differences in approaches to SME financing across transition regions. The Balkan model is characterized by a high share of public-private partnership projects, which indicates the maturity of the institutional environment. The Caucasus model is aimed at creating financial inclusion in the form of microfinance institutions and credit cooperatives.

The Eastern European model (except for Ukraine) follows a moderate strategy with respect to traditional banking instruments and new fintech products. Poland, the Czech Republic, and Hungary demonstrate the highest adoption of digital financial services among SMEs, a fact that is attributed to their accession to the EU.

As the authors have already noted, international financial institutions are catalysts in the development of SME finance ecosystems. The EBRD, the European Investment Bank, and the World Bank not only finance knowledge, but also transfer knowledge, standards, and best practices.

Technical assistance and capacity building are of particular importance. Statistics show an even higher success rate when comparing projects that include a technical assistance element to those based solely on financial instruments. This emphasizes the importance of a comprehensive approach to SME development.

Despite the fact that our research has yielded positive results, several of the problems identified can be considered systemic. First, it is subject to external shocks and changes in the priorities of foreign investors. Second, the concentration of aid in megacities contributes to regional disparities.

Third, poor coordination between different international donors will lead to wasted resources as well as duplication of efforts. The authors were told that on average, three to four support programs are available for SMEs in transition economies, but that there is a lack of coordination among these support programs.

The results of the study indicate that new methods of financing SMEs in transition economies are developing. In particular, financial social impact with a financial return, i.e. investments with a social impact, are showing an increase of 25% annually. The application of ESG criteria in the assessment of SMEs opens up new opportunities for access to international capital.

The digitalization of financial services is gaining momentum: the emergence of digital lenders, credit scoring using big data, and embedded financial services are all indications of how the traditional financing framework may be changing.

Analyzing the experience of transition economies, several general conclusions can be drawn about the future development of the SME finance system. First, it is crucial that financial instruments are tailored to local conditions and challenges. The case of Ukraine shows that such a radical change is possible in times of crisis.

Second, the effectiveness of SME support programs is linked to the stage of development of the entrepreneurship support ecosystem, such as educational programs, incubators, and mentor networks. Third, sustainability lies in creating a gradual transition from market mechanisms to donor funding.

An analysis of the experience of transition economies shows a wide variety of approaches to SME financing, depending on the specifics of economic development, institutional environment, and external challenges. The EBRD model is a successful example of a comprehensive approach that combines financial support with technical assistance and institution building. Ukraine's experience shows what is possible under conditions of great stress, and the experience of the Central Asian region shows what is possible through international mobilization of assistance to change the structure of the economy. Factors such as flexibility of instruments, breadth of approach, and organization of different stakeholders are also key success factors.

Discussion

The hierarchy of barriers authors systematized based on the literature review, where financial barriers have the highest frequency of mention (89%) among the six categories identified (financial, economic, institutional/corruption, infrastructure, governance, and gender/social), is supported by global statistics from the World Bank (2024), which shows that 40% of formal SMEs in developing countries have unmet financing needs worth $5.2 trillion annually. Meanwhile, our discussion builds on this understanding by demonstrating that financial barriers in transition economies are largely institutionalized. This is after a study by Ruziev and Midmore (2019) concluded that corruption and inefficient institutions impose transaction costs on SMEs that do not have access to traditional finance.

Of particular interest are our findings on the so-called threshold effect of financial literacy (a jump in success rates from 23% to 47%), which contrasts with linear models in developed economies. This may explain the peculiarities of transition economies, where simple financial competencies play a significant role in overcoming unfavorable institutional conditions, confirming the ideas of OECD (2022) about the importance of specific educational programs.

The authors found that the adoption of digital solutions is uneven (78–82% of basic technologies and 12–23% of innovative technologies), which is consistent with the findings of Ha et al. (2025), who identified three clusters of fintech development: obvious new services, market transformation, and the role of stakeholders. At the same time, a critical analysis of the shortcomings of the fintech development strategy compiled by Bernards (2019) is reflected in our statistical data, which indicate the gradual introduction of complex innovations in transition countries.

In 2025, Sullivan (2025) predicts rapid growth in instant payments: 94% in 2024 and up to 184 million mobile payment customers in 2026. These developments support our conclusions that the technology is disruptive, but the threat of AI fraud suggests that some form of trade-off must exist in transition economies with limited regulatory authority.

As the analysis of EBRD reports shows, a comprehensive approach combining financial instruments with institutional development is successful. This is in line with the study by Moscalu et al. (2018) on the importance of banking integration in reducing financial constraints for small and medium-sized enterprises in the euro area. However, our findings show that it is the flexibility of instruments in times of crisis (560% increase in guarantees) that is more important for transition economies than for stable European markets.

These findings are theoretically significant, as they contribute to the development of SME finance in transition economies in the context of a technological leap. The practical significance lies in the ability to demonstrate how financial systems can adapt almost instantaneously to problems, which is important for policy makers working in volatile environments.

Conclusions

This study has revealed a multi-level hierarchy of barriers to SMEs' access to finance in transition economies, with financial barriers predominating with a frequency of 89%, but closely linked to institutional, economic and social conditions. The study of the relationship between financial literacy and access to finance revealed a non-linear relationship, where a decisive gap of 23–47% (low and medium literacy) indicates the presence of a threshold effect in financial education.

The systematization of innovative solutions showed that simple solutions have become quite widespread and well adapted (mobile banking 78%, digital wallets 82%), while complex solutions are still at an early stage of development (blockchain 12%, crowdfunding 23%). The estimated exponential growth of blockchain finance (CAGR 55.9%) will show the transformational potential of decentralized financial solutions to overcome traditional barriers. Transparency has proven to be an important element in the success of financial programs, as a comparative analysis of the experience of transition countries has shown. As the Ukrainian experience shows, in difficult circumstances, SMEs can turn around in a very short time with the help of a support system, with portfolio guarantees actually increasing by 560% and new instruments being developed to help businesses in displacement. The Central Asia example has already demonstrated the success of integrating international assistance and local solutions, with 58% of EBRD investments including an environmental component.

The study confirmed that traditional and innovative sources of finance are not interchangeable. Blockchain/DeFi shows the best results in terms of speed (instant-24 hours) and transparency, while P2P lending provides the optimal balance between innovation and regulatory certainty. The smallest businesses need microfinance, even at high interest rates. The ability of countries to provide crisis support to SMEs varies considerably, highlighting the importance of fiscal capacity and financial institution maturity in terms of the sustainability of the small business finance system. The results of the study are of significant theoretical value, expanding knowledge about the peculiarities of SME financing in a transition economy, expanding the possibilities of overcoming traditional barriers through technological innovation and making a decent leap forward. It has practical implications for standardizing effective models and applying factors to the flexibility of the financial instrument in the direction of creating favorable conditions for people. The limitations of the study are that it is based on secondary data, which limits the scope of causal analysis; the focus is on European and Asian transition economies, and the timeframe may not be representative of long-term trends. The following areas should be explored in the future: a long-term study of the impact of digitalization on the structure of SME financing; a study of artificial intelligence in credit scoring; a study of different models of regulatory sandboxes; a study of the impact of geopolitics on international SME financing in transition economies.

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The Contribution of Agrotourism to the Development of Rural Areas

Gahraman Yusupov[1], Elshan Mammadov[2*], Ali Jabbarov[3], Rashad Safarov[2]

Abstract. *This article sets the task of thoroughly analyzing the impact of agritourism on the economic and social development of the village. The main goal of the study is to determine how agritourism affects the economic development of regions, the well-being of the local population and environmental protection. At the same time, the advantages of agritourism over mass tourism and its contribution to sustainable development are analyzed. The research questions provide a basis for determining what benefits agritourism brings to local communities in economic and social terms and to what extent activities in this direction are sustainable in the long term.The methodology of the study is based on an empirical approach. Quantitative and qualitative methods were applied during data collection. A total of 357 respondents were surveyed through a questionnaire. Respondent selection was carried out based on a combination of random and purposive methods. The collected data were analyzed using descriptive statistical analysis and comparative analysis methods. The results of the study show that the development of agritourism has a positive impact on the creation of additional jobs in rural areas, the increase in local production and the development of social infrastructure. It was found that attention to environmental protection has increased and the cultural values of the local population are actively promoted. The results also show that proper management of agrotourism facilitates the application of the principles of sustainable development. The originality of the study is due to the fact that the development potential of agrotourism in Azerbaijan is assessed on the basis of empirical data. The results of the study provide practical recommendations for tourism managers, local governments and business entities. This article contributes to the decision-making process related to planning and management of tourism development in rural areas.*

Keywords: *agrotourism, rural tourism, agriculture, local population, sustainable development, environment*

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[1]Qarabagh University, PhD in Economics, Karabakh, Azerbaijan
[2]Azerbaijan State University of Economics, PhD in Economics, Baku, Azerbaijan
[3]Nakhchivan State University, PhD in Economics, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: elshan_mammadov@unec.edu.az
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Aqroturizmin kənd ərazilərinin inkişafına töhfəsi

Qəhrəman Yusupov[1], Elşən Məmmədov[2*], Əli Cabbarov[3], Rəşad Səfərov[2]

Xülasə. *Bu məqalədə aqroturizmin kəndin iqtisadi və sosial inkişafına təsirini əsaslı şəkildə təhlil etmək vəzifəsi qarşıya qoyulur. Tədqiqatın əsas məqsədi aqroturizmin regionların iqtisadi inkişafına, yerli əhalinin rifahına və ətraf mühitin mühafizəsinə necə təsir etdiyini müəyyən etməkdir. Eyni zamanda, aqroturizmin kütləvi turizmə görə üstünlükləri və davamlı inkişafa verdiyi töhfələr təhlil*

olunur. Tədqiqat sualları aqroturizmin yerli icmalar üçün iqtisadi və sosial baxımdan hansı faydalar gətirdiyini və bu istiqamətdə fəaliyyətin uzunmüddətli dövrdə nə dərəcədə davamlı olmasını müəyyən etməyə əsas yaradır. Tədqiqatın metodologiyası empirik yanaşmaya əsaslanır. Məlumat toplanması zamanı kəmiyyət və keyfiyyət üsulları tətbiq edilmişdir. Sorğu anketi vasitəsilə ümumilikdə 357 respondent arasında sorğu keçirilmişdir. Respondent seçimi təsadüfi və məqsədli üsulların kombinasiyası əsasında həyata keçirilmişdir. Yığılan məlumatlar deskriptiv statistik təhlil və müqayisəli təhlil metodları ilə analiz edilmişdir. Araşdırmanın nəticələri göstərir ki, aqroturizmin inkişafı kənd ərazilərində əlavə iş yerlərinin açılmasına, yerli istehsalın artmasına və sosial infrastrukturun inkişafına müsbət yöndə təsir edir. Ətraf mühitin mühafizəsinə diqqətin artdığı və yerli əhalinin mədəni dəyərlərinin aktiv formada təbliğ olunduğu müəyyən edilmişdir. Həmçinin nəticələr onu göstərir ki, aqroturizmin düzgün idarəçiliyi davamlı inkişafın prinsiplərinin tətbiqini asanlaşdırır. Tədqiqatın orijinallığı onunla bağlıdır ki, Azərbaycanda aqroturizmin inkişaf potensialı empirik məlumatlar əsasında qiymətləndirilir. Tədqiqatın nəticələri praktiki baxımdan turizm idarəçiləri, yerli özünüidarəetmə orqanları və sahibkarlıq subyektləri üçün zəruri tövsiyələr təqdim edir. Bu məqalə kənd ərazilərində turizmin inkişafının planlaşdırılması və idarə olunması ilə bağlı qərarvermə prosesinə töhfə verir.

Açar sözlər: *aqroturizm, kənd turizmi, kənd təsərrüfatı, yerli əhali, davamlı inkişaf, ətraf mühit*

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[1]Qarabağ Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Qarabağ, Azərbaycan
[2]Azərbaycan Dövlət İqtisad Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[3]Naxçıvan Dövlət Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: elshan_mammadov@unec.edu.az
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Introduction

The organization of tourism in rural areas increases the recognition of these places, strengthens their economic well-being and affects the rise of the social status of the local population. In general, the organization of recreation in rural areas means getting away from the hustle and bustle of the city and entering a different environment.

The concepts of “countryside” and “village” usually evoke similar images: meadows, mountains, forests, rivers, villages, domestic animals, farmland, gardens, dirt roads and sparse population. When a person moves away from his permanent place of residence - whether to megacities, villages, rocky, desert or green areas - he enters a different environment. He wants to feel this difference, even for a short time.

Mass tourism is a form of tourism characterized by the simultaneous visit of large groups of people to popular tourist attractions. This type of tourism includes standard package tours aimed at a wide audience, and local features are often not taken into account. Istanbul, Rome, Madrid, Barcelona, Antalya, Paris, Singapore and other cities are popular destinations for this type of tourism. Mass tours mainly include excursion routes and visits to museums and famous man-made monuments.

Some tour operators organize hikes for tourists on foot, by bicycle, by motorbike, or by horse in natural areas, which creates a completely different experience. Participation of city dwellers in such hikes leads to their direct contact with the beauty of the green environment, as well as to their being more active in nature conservation.

Tourists passing through rural areas communicate with local residents and mutual impressions are exchanged. In recent years, tour operators in Azerbaijan have been organizing hiking tours in various regions of the country. The purpose of these tours is for our citizens to get to know not only the fascinating nature of our country, but also the historical monuments located in these areas. This communication is carried out both on a spiritual and material level.

As the local population's interest in rural tourism activities increases, their attention to environmental protection also increases. Valuing local resources creates a desire in rural communities to expand tourism activities in the future. Because tourists prefer well-preserved, uniquely attractive and properly marked areas. Nature and culture are the main components of tourism. Agritourism is geographically linked to specific areas. Therefore, the development of theoretical and methodological foundations for its development requires the definition of the concept of "agritourism" in a conceptual framework that is consistent with regional conditions and socio-economic prerequisites (Pecheritsa & Shevchenko, 2012).

In the experience of foreign countries, the concept of agritourism often appears as a synthesis of various, broad, and sometimes contradictory definitions (Pecheritsa & Shevchenko, 2012). The demands and lifestyle of agritourists have changed. They now prefer establishments that offer a variety of activities and services, based more on local characteristics and individual experiences (ISMEA, 2023). Tourism has been considered as an integral part of state strategies for solving development problems in rural areas for many years. Civelek and Karadağ (2020) note that the valuable contribution of tourism has encouraged state institutions to consider rural tourism as an alternative to mass "sun and beach" tourism.

According to the World Tourism Organization, rural tourism is a type of tourism activity where the visitor's experience is linked to a wide range of products related to nature-based activities, agriculture, rural lifestyle and culture, fishing, and visiting places of interest (World Tourism Organization, 2019). If we understand rural tourism as the sum of all recreational activities carried out in rural areas and based on elements of rural culture, then agrotourism is a form of rural tourism in which these elements are to some extent related to agricultural practices (Sayadi & Calatrava, 2001).

Agrotourism is a sustainable and alternative form of tourism based on both modern and traditional agriculture. Tourists can participate in various agricultural activities in direct contact with nature by staying in rural houses and guesthouses. Agrotourism also revitalizes the economy in rural areas and contributes to regional development (Civelek & Karadağ, 2020). In order to attract tourists to rural areas, it is important to organize rural product festivals and actively promote agrotourism, as these initiatives increase visibility, increase visitor interest and increase the overall attractiveness of rural areas.

According to Phillip et al. (2010), the first experience that comes to mind when discussing agrotourism activities is participating in activities carried out on an agricultural or farm. Second, tourists must participate in the activities directly, indirectly, or passively. Direct experiences include milking and harvesting; indirect experiences include preparing or selling food; and passive experiences include activities that take place off the farm. Third, it is important for tourists to feel a sense of authenticity in their agricultural experiences, as genuine interactions with local culture, farming practices, and rural lifestyles significantly enhance the overall quality and credibility of agritourism activities.

Ramos et al. (2017) confirm that agritourism is a sub-segment of rural tourism and is mainly carried out on farms. This type of tourism allows tourists to directly participate in agricultural activities and aims to attract visitors who value cultivated landscapes in particular. For agrotourism to be successful, efficient, profitable and competitive organic agriculture must be carried out. Also, specific routes and

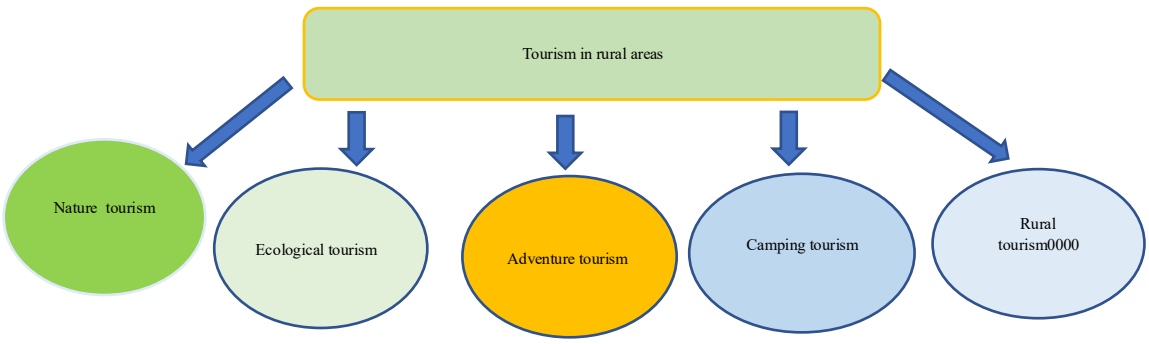
signage systems must be organized based on proper planning and organizational work. Other authors also associate agritourism with tourists working in agricultural enterprises. These include Telfer and Wall (2000), Williams et al. (2001), Sonnino (2004), Sayadi & Calatrava (2001) and others. It is clear that tourists do not receive any salary in exchange for the work they do and the products they obtain. In return, they are provided with food and accommodation by the farm owner. Agritourism is a form of tourism that involves spending time in a different environment, participating in the processes of growing, harvesting, processing and selling fruits and vegetables. A city dweller who voluntarily (without pay) participates in agricultural work gains certain skills and in return is provided with accommodation and food. The authenticity of the activities, the tourists' authentic perception of agricultural experiences and the opportunity to directly participate in real agricultural work are considered to be the main features of agritourism (Civelek et al., 2014). According to the Working Farm, Direct Contact, Authentic (WFDCA) concept, in agritourism tourists directly experience physical agricultural activities: for example, "pick-your-own" farms or participation in farm work. Phillip et al. (2010) agree with other researchers that this type of agritourism goes beyond the usual tourist environment and enters the "backstage" of agriculture (MacCannell, 1973). The products and activities in this category have been less studied in the literature than other types. One example is WWOOFing (Worldwide Opportunities on Organic Farms), where tourists work on a farm in exchange for accommodation and often food (McIntosh & Bonnemann, 2006). The labor-intensive nature of organic farming creates a large opportunity for WFDCA agritourism.

Methodology

In the research process, quantitative research methods based on an empirical approach were used to study the interest and trends in agritourism. Data collection was carried out using a survey method. The survey was conducted with the participation of a total of 357 respondents, which created a sufficient basis for conducting initial statistical generalizations. The selection of respondents formed a heterogeneous structure, covering different age groups, different areas of employment and places of residence. This approach allowed for a comparative analysis of the attitude of individual socio-demographic groups to agritourism. The questions used in the survey were closed and semi-closed and covered the level of general interest in agritourism, attitude to volunteer work on farms, types of activities that are most interested in rural areas, and directions for proposals for the development of agritourism. The collected data were analyzed using descriptive statistical methods (grouping, percentages and frequency distribution). The results were visualized and interpreted in the form of diagrams. Also, some behavioral differences were identified by applying the comparative analysis method across age groups. The theoretical generalization method was also used in the research. The empirical results obtained were compared with relevant scientific approaches.

Tourism in rural areas

Tours organized in the provinces differ in content (scheme 1).



Scheme 1

During nature tours, people often do not take into account the ecological and economic impact they have on the environment by participating in activities such as hunting, fishing, rafting, hiking. During ecological tours, tourists immerse themselves in the mysterious beauty of nature, gain some information about flora and fauna, participate in tree planting or environmental cleaning campaigns. Ecotourism distinguishes itself by its environmental protection and study (research), as well as research activities. Adrenaline-seeking tourists overcome rocky terrain and difficult routes during adventure tours. Tourists staying in camps usually participate in hikes in various directions during their stay (on foot, with animals, by bicycle and motorcycle). Rural tourism, on the other hand, is completely different from all these types of tourism listed. The main function of rural tourism is to effectively improve the psychological and physical condition of a person.

Among the economic functions, the following should be especially noted:
• Creation of a sales market for specific resources belonging to rural areas.
• This creates financial resources for market activities and stimulates the economic development of rural areas.

The main reason why city dwellers choose to relax in the countryside is the desire to get away from the hustle and bustle of the city and explore the vast expanses of the countryside.
How many places can a villager offer a tourist to spend the night?
Part of the house where a village family lives:
• 1, 2, 3 rooms or 1 floor;
• A separate building built in the yard.
What services can tourists (family, friends, group mates) take advantage of when staying with a village family?

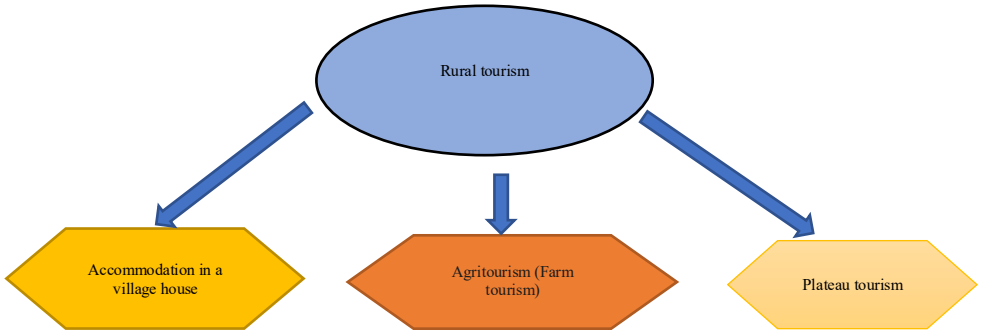
In the house, they can use the rooms provided for overnight stays and use household appliances. In the courtyard, tourists can relax, enjoy shaded areas decorated with roses, or use recreational facilities designed for children. Such arrangements provide both comfort and an immersive experience of village life for visitors.

Tourists pay the host for the services provided.
Tourists often want to volunteer to care for the pets kept by the village family and to tend to the plants grown in the garden, and in most cases, the host is positive about this.

Advantages for tourists
• They get away from the noise of cities and the polluted atmosphere created by industrial enterprises and cars.
• They eat food made from natural products. They gain a different life experience by living in accordance with the environment and daily lifestyle of a village family.
• They get acquainted with examples of local cuisine.
• They closely study the lifestyle and traditions of the village population, and observe local life from the inside.
• They establish closer contact with nature by participating in activities such as nature walks, hiking, fishing, and horse riding.
• They get acquainted with local culture, customs, and folklore heritage.
• They broaden their worldview and increase their knowledge about different cultures and lifestyles.

Benefits for local villagers

• Awareness increases: In order to improve the quality of services provided to tourists, villagers gain additional knowledge about the history, cultural life and traditions of their villages and regions. This creates conditions for the preservation and revival of local customs.
• Ecological awareness: Villagers begin to pay more attention to environmental protection.
• Expanding worldview: Communication with tourists leads to an increase in the knowledge and experience of villagers.
• Additional income: A new source of income is created.
• Attention to ecology: Local residents are more sensitive to the ecological balance, since a violation can lead to a decrease in the flow of tourists.
• Increased employment: The expansion of services for tourists increases employment in the village. As the economic opportunities of the villagers increase, their social situation also improves, and their chosen lifestyle, cultural values, and leisure time organization become richer and more meaningful. Recreation organized in the village family and in the village space can be divided into 3 groups (scheme 2).



Scheme 2

The above information is about the tourist's stay in a rural guesthouse and the benefits he gets from it. Agrotourism - as a broader service area - involves the voluntary participation of tourists in the activities of agricultural (farm) farms. Agritourism, as a branch of rural tourism, is characterized by the voluntary labor activities of tourists on rural farms. The systematic explanation of the concept of "agritourism" is based on the concepts of both "tourism" and "agriculture". In Italy, at a time when both domestic and foreign tourists are making higher demands, there is a need to specialize in agritourism and provide more services. In this context, training plays an important strategic role - the development of skills in this area is required in order to be able to respond professionally and efficiently to market demands. Agrotourism is the most widespread form of diversification in agriculture and has developed widely in rural areas, socio-economically disadvantaged areas, mountainous areas and small settlements in Italy (ISMEA, 2024). Although it has similarities with rural tourism and farm tourism, agritourism includes agricultural activities, such as viticulture, in its environment. On the other hand, rural tourism and farm tourism can also include camping, handicraft fairs, safari tours, adventure sports, hiking routes and other tourism activities carried out in rural areas (Şanlıer & Gazelci, 2024). As can be seen, numerous types of services are offered to tourists who choose the village as a recreation destination. In general, it can be noted that agritourism creates diversification and additional income opportunities for rural family farms, which has a positive impact on increasing employment and economic development in rural areas. This has also been defined as an explicit objective in various support programs (Deutsch-Russischer Agrarpolitischer Dialog, 2020). Some researchers have suggested that farm tours, which are conducted on working farms and allow tourists to participate directly in agricultural activities, are an authentic model of

agritourism. In this case, tourists contribute labor to the farm in exchange for accommodation and food (McIntosh & Bonnemann, 2006).

Tourists' grouping by recreational purpose
Tourists who relax in rural areas can be divided into two groups according to their purpose:
1. Simply staying in a village house and enjoying the hospitality of the host
This includes:
• overnight stay,
• meals,
• getting to know the courtyard and the village environment,
• walking around the village and its surroundings,
• observing the lifestyle of a village family.
2. Volunteering in agriculture
Motives can be varied:
a) To experience agriculture from the inside for a certain period of time
b) To learn the dialect of the local population (philological research)
c) To learn or improve German, English, Italian, etc. languages, local dialects
d) To get acquainted with the agricultural production process of the local population (planting, harvesting, processing, sales; viticulture, grain growing, rice growing, fruit growing, etc.)
e) Other reasons.
Unlike group 1 tourists, group 2 tourists are provided with accommodation and food because they work voluntarily in agriculture.

Tourists who stay in a village house for the sole purpose of recreation do not follow a regime - they eat when they want, go where they want. Agrotourists, on the other hand, must adhere to a certain regime. Because they are obliged to follow the instructions of the farm owner: in which field, with what tool, and for how many hours they will work, they are informed in advance. If the requirements are not met, the farm owner either demands a service fee from the tourist or removes him from the farm. Not every tourist wants to spend his entire vacation in a cotton field, tea plantation or apple orchard. As a rule, a tourist is content with 2–4–7 days of activity and gets the necessary impression.

The role of state support in the development of agritourism

The role of agritourism is particularly emphasized in the Italian General Strategic Partnership Plan for 2023–2027. The implementation of this plan envisages increasing the attractiveness of the region, increasing the demand for ecosystem services and increasing employment by strengthening the multifunctionality of agriculture (ISMEA, 2023). Rural product festivals and the promotion of agritourism are important for the promotion of agricultural products.

Highland tourism

One of the most interesting areas of rural tourism is highland tourism.

Highlands are economic areas located outside permanent settlements where people engage in animal husbandry and agriculture. Some are collectively owned by communities, while others are state-owned. From a socio-economic perspective, highlands are a complementary part of the agricultural economy (Çalık et al., 2021). Living with shepherds for a while, observing their lifestyle, looking at animals, and spending leisure time in a different environment are some of the main aspects of this type of tourism.

To accommodate volunteers, the farm must be provided with a certain infrastructure: accommodation, conditions for participation in agricultural work, food opportunities, necessary facilities for training

in agricultural activities. Modern agrotourists now prefer farms that offer a wider range of activities and personalized experiences (ISMEA, 2023). The farm owner may not always be satisfied with the work of the tourist. Dissatisfaction arises between the parties when the tourist does not perform the work assigned to him with the required quality. Situations such as the sound of agricultural machinery in the early morning, the smell of fertilizer or the application of pesticides sometimes lead to disputes. To overcome these difficulties, it is important for farm owners to be patient and sensitive to the expectations of guests (Deutsch-Russischer Agrarpolitischer Dialog, 2020). Tourism related to agriculture is very little used in Azerbaijan. In many foreign countries, agrotourism is a fairly mature tourism sector. It has gone through certain stages of development and formation, and therefore can be a necessary and valuable example for the development of agrotourism in Azerbaijan. As an alternative form of tourism, agrotourism is considered a deeper category within rural tourism and is a type of tourism of particular interest. Agriculture offers a significant opportunity in responding to consumers' demand for fresh, minimally processed, healthy, ethically and sustainably produced foods that are beneficial to their quality of life and health. Agrotourists take advantage of these opportunities.

Rural tourism or the development of tourism in a rural environment?
Some of the main questions here may be:
1. What are the farmer's motives?
a. Economic?
b. Communication with new people and perhaps broadening their worldview?
2. What are the motives of a rural tourist?
a. A different environment and experiencing rural life here,
b. Communication with people with different views,
c. Broadening their worldview.
Unlike a hotel, the accommodation provided in a rural guesthouse can meet simple elementary requirements. The European Rural Tourism Association has adopted certain standards for rural guesthouses. However, rural guesthouses do not always meet these standards. This is because not every homeowner can fully adapt his house or part of his house to the conditions that will meet certain standards. Perhaps, since the conditions in rural guesthouses are non-standard, they create opportunities for tourists to get closer to rural life.

In Spain, state support for the development of agritourism has not been in line with the initial plan of community institutions to promote rural tourism as a source of additional income for farmers (Pulido & Cárdenas, 2011). Instead, it has continued to favor the idea of tourism as a source of foreign exchange by attracting as many tourists as possible without considering the environmental or social costs (Espinosa & Aldana, 2023). However, by the beginning of the century, tourism had started to show undesirable results. This was due to the fact that in many cases the projects were not related to agriculture, but rather were foreign investments based on seasonal businesses that did not benefit local communities. Many public and private strategies for rural tourism focused on increasing short-term supply without taking into account territorial imbalances, supply quality and long-term sustainability of the product (Cánoves et al., 2012). In this context, according to studies carried out in Spain , despite the increase in the number of tourists and overnight stays in rural areas in the last two decades, the average annual occupancy rate remained around 20% and the average length of stay barely exceeded three nights. In this case, it can be concluded that rural tourism has not reached the level of mass tourism. However, the absence of mass tourism in rural tourism is a key attractive factor for this type of tourism. In Azerbaijan, the Ministry of Agriculture has implemented projects to attract rural residents to tourism activities (Dövlət Turizm Agentliyi, t.y.) and the Ministry of Labor and Social Protection of the Population has implemented projects to support individual entrepreneurship, including the expansion of rural tourism activities. Within the framework of these projects, household appliances and household equipment were provided to rural residents who wanted to receive tourists and provide them with accommodation and food services. However, no information was provided to a wide audience about the number of tourists received as a result of these projects and the volume of

services provided to them. In particular, it is impossible to obtain information about the number of tourists involved in agricultural work.

Promotion of rural tourism

The development of rural tourism helps to prevent the complete abandonment of local populations from their regions – especially mountainous, rocky and saline areas – and at the same time contributes to the preservation and protection of local customs and traditions. In order to promote rural tourism, it is necessary to activate sectoral policies and fulfill certain tasks. These tasks include the following:

• Ensuring full access to the transport network;
• Increasing interest in natural areas and protected areas, making them more accessible for tourism;
• Creating an internet and information technology infrastructure in these regions;
• Improving the marketing skills of agricultural producers and expanding access to local markets so that accommodation and public catering establishments can easily obtain the necessary local products.

In order to promote tourism and attract tourists – both in groups and individually – to certain areas, it is necessary to continuously prioritize the installation of road signs leading to anthropogenic and natural objects, the placement of information boards in cultural and natural sites, the construction of roads, the implementation of marketing activities and the improvement of the quality of services provided in rural tourism in general. It is also important to follow European trends in this area and apply benchmarking techniques (Karpenko et al., 2017).

Another factor – geographical indications – makes an important contribution to the development of agrotourism. Products registered with a geographical indication are distinguished both in terms of standardization and in terms of production characteristics specific to the region. Therefore, agricultural products identified with geographical indications support agrotourism. In addition, geographical indications play an important role in the formation of the gastronomic identity of the region through the cultivation, marketing and registration of products specific to the region (Şanlıer & Gazelci, 2024). Conducting surveys on rural tourism among broad segments of the population is itself an option for promoting rural tourism. Thus, the results of the survey conducted by us were as follows:

A total of 357 people participated in the survey. Participants covered a wide range of age, place of residence, and work activities. 180 people answered “yes” to the question “Are you interested in volunteering on a farm during your vacation in the countryside?” (Chart 1).

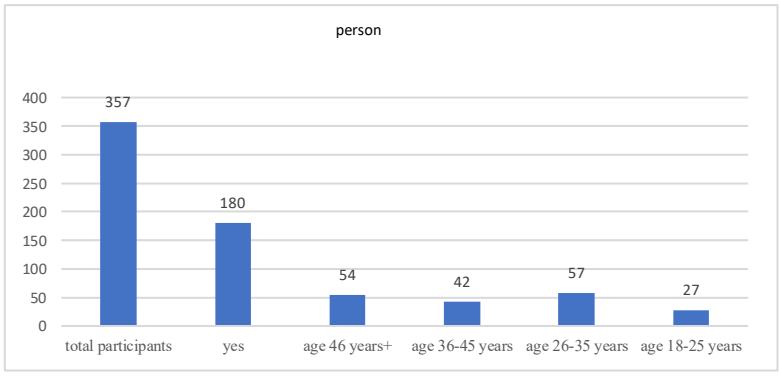


Chart 1

Those interested in volunteering on a farm during their vacation in the countryside

As can be seen from the diagram, out of 180 people who want to volunteer on a farm, the share of those under 25 years of age is lower among those who say “yes” overall. Those over 26 years of age prefer this activity more.

Although the survey participants did not want to volunteer on a farm, they noted that they would like to participate in fruit picking and take care of animals for a short period of time. 118 of the participants answered “yes” to the question “does a vacation in a country house attract you?” 84 people indicated “agriculture” to the question “your main area of interest.” The main results of the survey are reflected in the following diagrams:

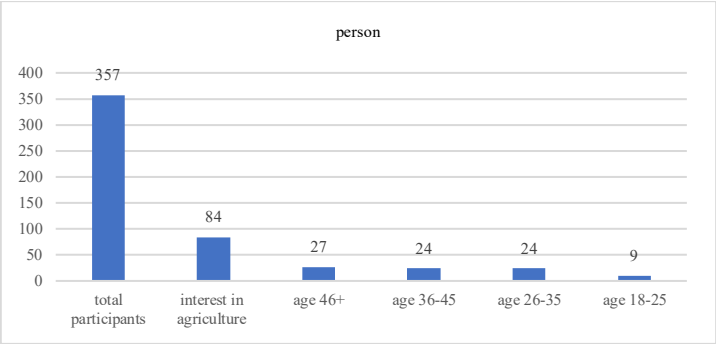


Chart 2

The main area of interest when relaxing in a country house

When answering the survey questions, participants indicated a preference for "nature" (92 people), "tranquility" (88 people), and "rural culture" (39 people) as their main areas of interest, in addition to "interest in agriculture". Preferred activity when relaxing in a country house.

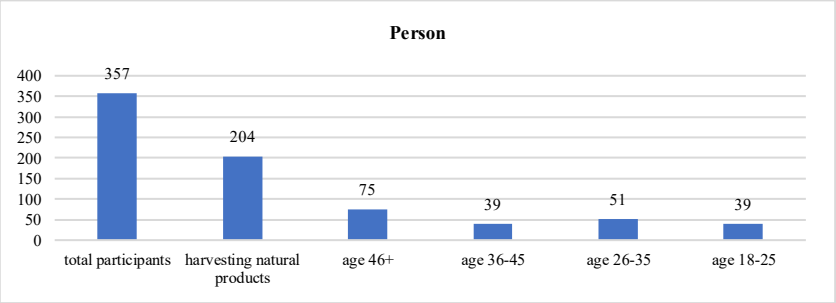


Chart 3

Preferred activity when relaxing in a country house

When asked “What activities do you prefer to do while relaxing in a rural house?”, 204 people answered “collecting natural products.” At the same time, as passive activities, survey participants noted “handicrafts” (33 people) and “hiking in nature” (117 people). There were various answers to the question “What are your suggestions for developing rural tourism?”. These mainly include: landscaping of rural areas, state support, education of rural residents (on tourist services), advertising, installation of signs in the direction of rural guest houses. Survey participants particularly emphasized the improvement of road infrastructure in rural areas. The region should constantly offer new values. To achieve this, it is necessary to develop attractive criteria that meet the needs of target groups. The smaller the region, the more unique and original the proposals should be. Exoticism is one of the main criteria for attracting tourists (Yusupov, 2021). Municipalities and state agencies should encourage the creation of rural tourism associations and organize training in this direction. State support programs are of great importance in stimulating private household investment in the tourism sector. The accommodation offered in rural houses can vary in terms of form, amenities, and comfort level. Before choosing a place to stay, each tourist receives detailed information about the amenities offered here. Usually, tourists have a certain impression of hotel rooms: comfortable beds, tables, chairs, bathrooms, televisions, Wi-Fi, and other services. Virtual reality technologies are interesting not only

for young people who are constantly interacting with virtual reality, but also for the older generation due to their high mobility and convenience (Liu et al., 2026). At the same time, the amenities offered in rural guest houses can be completely different. These amenities range from VIP-level accommodations to overnight stays in haylofts or the simplest, most minimal amenities. Stays in haylofts usually last 1–2 nights and rarely last longer. Rural houses with the simplest living conditions are often rented by city dwellers for the entire summer season. The main requirements are that the bed and bathroom facilities are clean and tidy, and that the kitchen equipment is in working order. One of the forms of agrotourism is one-day trips organized by tour operators for tourists to agricultural enterprises. At this time, tourists participate in the harvest, helping the farmer for 1–2 hours, and at the same time buying the products they have collected for themselves and taking them home. Such tours are widespread in Azerbaijan.

Conclusion

Agritourism is becoming more and more important every day — it contributes to the development of villages, combines agriculture, culture and ecology, and is easily integrated with other types of tourism. For the successful operation of a business, it is necessary to comprehensively use marketing tools, from basic surveys to conducting marketing research using SWOT analysis, PEST analysis and other methods to identify customer preferences. Unlike mass tourism, agritourism is carried out in small groups and usually brings great benefits to the local population. In this regard, agritourism, which is a form of sustainable tourism, is considered an important tool for the development of villages, especially by improving the income and socio-cultural conditions of the local community in the area. Agrotourism is becoming more and more important every day and attracts attention mainly due to its contribution to the development of rural areas and the unique activities it encompasses. It is closely related to culture, nature and the environment, is integrated with agriculture, embodies cultural values and can be easily combined with other forms of tourism. In short, agrotourism is a branch of rural tourism. The word "agro" is a shortened form of the words "agronomic" or "agriculture". It is derived from the Greek word agronomos, where agros means "field, land" and nomos means "law, administration". The term "agro" has the same meaning in almost all languages and is used to describe agricultural activities. In simple terms, if you see a word starting with "agro", know that it is directly related to working with the land and producing food.

Main features of agrotourism

• Accommodation: Overnight stay on a working farm or with a rural family.
• Active participation: Direct involvement of tourists in agricultural activities.
• Authenticity: Experiencing real rural life.
• Educational function: Increasing knowledge about the nature of food production and agricultural labor.

As a result, agrotourism is not only a replacement of the urban environment with the rural environment, but also an opportunity to enter a unique lifestyle, try out the role of a farmer and gain new knowledge.

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Information Obesity, Digital Addiction, and Economic Productivity: Empirical Evidence from Turkey

Rahiba Abdulhasanova[1], Aysegul Babaoglu[2], Sadagat Ahmadova[3*], Flora Alasgarova[4], Tural Abdulhasanov[5]

Abstract. *This article examines the underexplored nexus between information obesity, digital addiction, and economic productivity in Turkey, drawing on a multi-level analytical framework that integrates labour economics, digital studies, and organisational behaviour. While Turkey has experienced rapid digital transformation—with internet penetration reaching 90.9 per cent in 2025—this expansion has been accompanied by rising technostress, workplace distraction, and digital dependency, particularly in major urban centres such as Istanbul and Ankara. Synthesising empirical evidence from cross-sectional surveys, sectoral studies, and national statistical data, the article demonstrates that information overload and compulsive digital engagement erode labour productivity through mechanisms including reduced attention, cognitive fragmentation, weakened safety culture, and diminished work–life balance. These effects are mediated by gender, socioeconomic status, and regional disparities, with women and lower-educated workers disproportionately affected. The article argues that neoliberal labour market reforms have inadvertently fostered digitally saturated work environments that compound the productivity challenge. Policy recommendations advocate for a multi-tiered intervention strategy encompassing mandatory media literacy education, workplace digital well-being programmes, and regionally sensitive digital inclusion initiatives. In so doing, the article situates information obesity within a developing-economy context and proposes a conceptual framework linking habitual digital overconsumption to productive capacity—a connection that the economics literature has been slow to theorise.*

Keywords: *information obesity, digital addiction, labour productivity, Turkey, technostress, neoliberal policy, digital inclusion, cognitive overload*

[1]Nakhchivan State University, PhD student, Nakhchivan, Azerbaijan
[2]Kocaeli University, Doctor, Kocaeli, Turkey
[3]Nakhchivan State University, PhD in Economics, Nakhchivan, Azerbaijan
[4]Azerbaijan Tourism and Management University, PhD in Economics, Baku, Azerbaijan
[5]Azerbaijan State University of Economics, PhD in Economics, Baku, Azerbaijan
[*]Corresponding author. E-mail: sedaqet.ahmedova@bk.ru
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İnformasiya yüklənməsi, rəqəmsal asılılıq və iqtisadi məhsuldarlıq: Türkiyədən empirik sübutlar

Rahibə Əbdülhəsənova[1], Ayşegül Babaoğlu[2], Sədaqət Əhmədova[3*], Flora Ələsgərova[4], Tural Əbdülhəsənov[5]

Xülasə. *Bu məqalə Türkiyədə informasiya piylənməsi, rəqəmsal asılılıq və iqtisadi məhsuldarlıq arasındakı kifayət qədər araşdırılmamış əlaqəni əmək iqtisadiyyatı, rəqəmsal tədqiqatlar və təşkilati davranışı birləşdirən çoxsəviyyəli analitik çərçivə əsasında təhlil edir. Türkiyədə sürətli rəqəmsal transformasiya prosesi baş vermiş və 2025-ci ildə internetdən istifadə səviyyəsi 90,9 faizə çatmışdır. Lakin bu genişlənmə, xüsusilə İstanbul və Ankara kimi böyük şəhərlərdə texnostressin, iş yerində diqqət yayınmasının və rəqəmsal asılılığın artması ilə müşayiət olunmuşdur. Kəsişən sorğular, sektor tədqiqatları və milli statistika məlumatlarının empirik təhlilinə əsaslanan məqalə göstərir ki, informasiya yüklənməsi və rəqəmsal texnologiyalardan kompulsiv istifadə əmək məhsuldarlığını azaldır. Bu təsir diqqətin zəifləməsi, koqnitiv parçalanma, təhlükəsizlik mədəniyyətinin zəifləməsi və iş-həyat balansının pozulması kimi mexanizmlər vasitəsilə baş verir. Məqalədə qeyd olunur ki, bu təsirlər gender, sosial-iqtisadi status və regional fərqlər tərəfindən vasitələndirilir; xüsusilə qadınlar və təhsil səviyyəsi aşağı olan işçilər bu problemlərdən daha çox təsirlənirlər. Tədqiqat iddia edir ki, neoliberal əmək bazarı islahatları qeyri-ixtiyari şəkildə rəqəmsal informasiya ilə həddindən artıq yüklənmiş iş mühitlərinin formalaşmasına şərait yaratmış və bununla da məhsuldarlıq problemini daha da dərinləşdirmişdir. Siyasət tövsiyələri media savadlılığı üzrə məcburi təhsil proqramlarını, iş yerlərində rəqəmsal rifah proqramlarını və regional xüsusiyyətləri nəzərə alan rəqəmsal inklüzivlik təşəbbüslərini əhatə edən çoxsəviyyəli müdaxilə strategiyasını dəstəkləyir. Bununla da məqalə informasiya piylənməsi problemini inkişaf etməkdə olan ölkə kontekstində qiymətləndirir və vərdiş halını almış həddindən artıq rəqəmsal istehlak ilə məhsuldar fəaliyyət qabiliyyəti arasında əlaqəni izah edən konseptual çərçivə təklif edir. Bu əlaqə iqtisadiyyat ədəbiyyatında indiyədək kifayət qədər nəzəri əsaslandırılmamışdır.*

Açar sözlər: *informasiya piylənməsi, rəqəmsal asılılıq, əmək məhsuldarlığı, Türkiyə, texnostress, neoliberal siyasət, rəqəmsal inklüzivlik, koqnitiv yüklənmə*

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[1]Naxçıvan Dövlət Universiteti, doktorant, Naxçıvan, Azərbaycan
[2]Kocaeli Universiteti, Doktor, Kocaeli, Türkiyə
[3]Naxçıvan Dövlət Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[4]Azərbaycan Turizm və Menecment Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[5]Azərbaycan Dövlət İqtisad Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: sedaqet.ahmedova@bk.ru
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Introduction

There is something deeply paradoxical about the digital age. The same technologies that have liberated millions from information scarcity are now drowning them in information excess. In Turkey, this paradox is particularly vivid. A country that only two decades ago struggled with basic internet connectivity now boasts an internet penetration rate of 90.9 per cent among individuals aged 16–74, according to the Turkish Statistical Institute's 2025 survey (TurkStat, 2025). Yet this remarkable digital expansion has not been accompanied by a proportionate rise in labour productivity. If anything, the productivity picture has grown murkier. The OECD's 2025 Compendium of Productivity

Indicators conspicuously excludes Türkiye from its aggregate calculations, hinting at measurement challenges that may themselves be symptomatic of a deeper structural malaise (OECD, 2025).

The concept of 'information obesity'—the excessive, often compulsive accumulation and consumption of digital information beyond what an individual can meaningfully process—remains surprisingly underdeveloped in the labour economics literature. This is a striking omission. We have long known that the quality and quantity of information available to workers shapes their decision-making capacity, their ability to prioritise tasks, and ultimately their productive output. Yet as the volume of available information has grown exponentially—through emails, social media notifications, instant messaging, news feeds, and algorithmic content recommendations—the analytical focus has remained overwhelmingly on information access rather than information excess. This article seeks to redress that imbalance.

Fieldwork observations across Turkish academic and professional settings point to a palpable shift in how both university students and working professionals interact with information. Students increasingly report difficulty sustaining attention during lectures—not because the material is uninteresting, but because the constant pull of notifications, social media feeds, and messaging applications fragments their cognitive resources. Similarly, professionals in Istanbul and Ankara's banking and service sectors describe a kind of perpetual cognitive overload: a feeling of always processing but never quite finishing, always connected but rarely productive. These practitioner accounts, while qualitative, align closely with the empirical evidence reviewed in this article and suggest that information obesity is not merely a theoretical construct but a lived reality with tangible economic consequences.

Methods

This article makes three principal contributions. First, it synthesises dispersed empirical evidence on the productivity consequences of information overload and digital addiction in Turkey, drawing on sources from labour economics, organisational behaviour, and digital studies. Second, it develops a multi-level analytical framework that captures how neoliberal policy structures, socioeconomic mediators, and individual digital behaviours interact to shape productivity outcomes. Third, it proposes a comprehensive, multi-tiered policy response that addresses the problem simultaneously at the educational, organisational, and governmental levels—an approach that is the only one commensurate with the scale and complexity of the challenge.

The remainder of the article is structured as follows. Section 2 reviews the theoretical and empirical literature on information obesity, technostress, and digital addiction as they relate to labour productivity. Section 3 presents Turkey's digital landscape through statistical evidence. Section 4 examines the productivity consequences of information obesity and digital addiction in the Turkish context. Section 5 analyses the mediating roles of gender, socioeconomic status, and regional context. Section 6 explores the structural contribution of neoliberal policies to digitally saturated work environments. Section 7 develops policy recommendations, and Section 8 concludes.

Theoretical and empirical foundations

The term 'information obesity' has gained traction in popular and semi-academic discourse, yet it lacks a settled definition in the economics literature. Drawing on the broader concept of information overload—which has roots in Herbert Simon's (1971) foundational argument that an abundance of information necessarily impoverishes the attention available to process it—I define information obesity as the sustained overconsumption of digital information at a rate and volume that exceeds an individual's processing capacity, leading to measurable decrements in cognitive functioning, decision-making quality, and productive output. Unlike simple information overload, which may be

episodic and situational, information obesity implies a chronic condition—a habitual pattern of digital consumption that has become structurally embedded in daily routines, work practices, and social expectations.

The distinction matters for policy. If information overload is a temporary spike that resolves when a deadline passes or a project concludes, it calls for individual coping strategies. If information obesity is a chronic condition sustained by structural incentives—platform design, workplace norms, algorithmic curation—it calls for systemic intervention. The evidence reviewed in this article suggests that for a growing number of Turkish workers, the latter characterisation is more apt.

The existing literature has approached related problems from several angles. In organisational psychology, the concept of 'technostress' captures the strain that arises when workers feel compelled to remain constantly connected and responsive to digital communications (Yildirim & Ansal, 2014). In information science, Bawden and Robinson (2009) have documented how the exponential growth of available information creates 'information anxiety' and decision paralysis. In behavioural economics, the concept of 'choice overload' demonstrates that excessive options can impair rather than enhance decision quality. What the literature still lacks, however, is a framework that connects these individual-level findings to national productivity outcomes in a specific country context—which is precisely what this article attempts.

Digital addiction—defined as the compulsive, poorly controlled use of digital devices and platforms despite awareness of negative consequences—has been extensively studied from clinical and psychological perspectives. The global prevalence of internet addiction varies between approximately 8 and 40 per cent depending on the population studied and the measurement instrument employed, while smartphone addiction affects an estimated 27 per cent of users worldwide (Cheng & Li, 2014; Sohn et al., 2019). What economists have largely overlooked, however, is what this means for output: the aggregate productivity cost when large numbers of workers are caught in patterns of compulsive digital use throughout the working day. Doğan (2026), in a phenomenological study currently in press, reports that compulsive device use among Turkish employees leads to significant workplace distraction, diminished safety perception, and weakened collective responsibility. As a qualitative, in-press source, this study should be read as indicative rather than conclusive; its value lies in capturing something that quantitative surveys often miss—the lived experience of workers who recognise that their digital habits are undermining their performance but feel powerless to change them. The parallels with substance addiction—the sense of compulsion, the failed attempts at self-regulation, the social normalisation of the behaviour—are not merely metaphorical. They reflect neurological reward pathways that have been extensively documented in the broader addiction literature.

Among youth, the evidence is equally concerning. Sert et al. (2019) found that technology addiction among Turkish university students was significantly associated with lower academic achievement and increased fatigue, while Çelikkaleli et al. (2025) demonstrated that problematic internet use mediates the relationship between digital game addiction and motivation among Turkish adolescents. Boyacı (2019), in a content analysis of Turkish internet addiction research, noted that studies are overwhelmingly quantitative and cross-sectional, pointing to a methodological gap that limits our ability to draw causal inferences about the productivity effects of digital addiction. The concept of the 'productivity paradox'—first articulated by Robert Solow's (1987) famous quip that 'you can see the computer age everywhere but in the productivity statistics'—remains surprisingly relevant nearly four decades later. Despite massive investments in digital infrastructure and rapid adoption of information and communication technologies (ICTs), productivity growth across OECD countries has been sluggish, averaging just 0.4 per cent in 2024 excluding Türkiye (OECD, 2025). This raises an uncomfortable question: could it be that the very technologies adopted to enhance productivity are, through the mechanism of information obesity and digital addiction, partially undermining that goal?

Results

Berke, Akarsu, and Obay (2017) document a positive association between ICT adoption and economic growth in Turkey and the broader Balkan and Eastern European region. Yet their analysis, like most in this literature, measures technology diffusion rather than the quality of technology use. A country can have high internet penetration and extensive ICT adoption while simultaneously experiencing productivity losses from the misuse, overuse, or compulsive use of those same technologies. This article argues that Turkey exemplifies precisely this condition. Yildirim and Ansal's (2014) study of Turkish banking professionals offers an early empirical anchor for this argument, documenting how mobile technologies—adopted to streamline work—progressively generate technostress and fragment sustained attention. The mechanisms through which these dynamics translate into productivity losses in the Turkish context are examined in detail in Section 4.

A note on methodology is warranted. This article does not generate new primary data; rather, it conducts a critical synthesis of existing empirical studies, national statistical surveys, and sectoral research bearing on information obesity and digital addiction in Turkey. The review follows a systematic scoping approach: sources were identified through database searches (Google Scholar, Scopus, Web of Science) using the terms 'information overload,' 'digital addiction,' 'technostress,' 'labour productivity,' and 'Turkey,' supplemented by citation tracking and official statistical repositories (TurkStat, OECD, DataReportal). Inclusion criteria prioritised peer-reviewed empirical studies published since 2010 alongside key national statistical releases. The article's contribution lies in synthesising this dispersed evidence within a coherent multi-level analytical framework and deriving policy implications specific to the Turkish context.

Turkey's digital landscape: A statistical portrait

To understand how Turkey's digital transformation has affected productivity, it helps to first map the scale of that transformation. Table 1 presents the key indicators across a five-year window, and the picture that emerges is one of rapid, sustained digital expansion.

Table 1
Key digital indicators for Turkey, 2020–2025

Indicator	2020	2024	2025
Internet penetration (% of 16–74 age group)	79.0	88.8	90.9
Male internet users (%)	84.7	92.2	93.6
Female internet users (%)	73.3	85.4	88.2
E-government service usage (%)	51.5	73.7	76.1
Online shopping participation (%)	36.5	51.7	55.7
WhatsApp usage among internet users (%)	N/A	86.2	88.6
YouTube usage (%)	N/A	71.3	72.9
Instagram usage (%)	N/A	65.4	68.1
Online learning participation (%)	N/A	13.8	17.7
Social media user identities (millions)	~54.0	~57.5	~58.5

Source: Compiled from TurkStat ICT Usage in Households and by Individuals Survey (2020, 2024, 2025); DataReportal Digital 2025: Turkey; Kepios analysis (2025).

A few features of these data are worth drawing out. First, the gender gap in internet access, while narrowing, remains persistent: in 2025, women's internet usage still lagged men's by 5.4 percentage points. This gap has implications for the gendered distribution of information obesity's effects, as I discuss in Section 5. Second, the explosive growth in social media usage—with WhatsApp, YouTube, and Instagram collectively dominating Turkish digital life—creates an environment in which informational overconsumption is not merely possible but structurally incentivised by platform design. These platforms are engineered, through infinite scrolling, autoplay, push notifications, and algorithmic personalisation, to maximise engagement time rather than information quality. Third, the relatively modest rate of online learning participation (17.7 per cent) suggests that for most Turkish internet users, digital engagement is oriented more towards consumption and communication than towards skill development—a troubling imbalance from a productivity standpoint.

Behind these figures lies a more immediate reality. A 2022 survey by Turkey's Radio and Television Supreme Council (RTÜK) found that Turkish adolescents and young people aged 15–21 spent an average of 4 hours and 37 minutes daily on technological devices, with social media applications consuming the largest share of that time (RTÜK, 2022). Among European countries, Turkey stands out with average smartphone usage exceeding 4 hours and 16 minutes daily—one of the highest rates on the continent. When one considers that these figures likely understate actual usage (self-reported screen time data consistently fall below objective measurements), the scale of the information consumption challenge becomes clear.

Table 2
Comparative digital engagement and productivity indicators

Country	Internet penetration (%)	Avg. daily smartphone use (hrs)	GDP per hour worked (USD PPP)
Turkey	90.9	4.27	~53.4
Germany	93.1	3.01	~79.2
United Kingdom	96.7	3.45	~72.1
South Korea	97.6	3.54	~52.8
United States	95.3	4.42	~85.6
OECD average	~89.0	~3.50	~67.1

Source: Compiled from TurkStat (2025); DataReportal (2025); OECD Productivity Database (2023–2024); DemandSage (2025). Note: GDP per hour worked figures are approximate and based on latest available data.

Table 2 reveals a suggestive pattern. Turkey combines relatively high internet penetration and smartphone usage with comparatively low labour productivity. It must be stressed that this six-country comparison is illustrative rather than analytical: without controls for capital intensity, sectoral composition, institutional quality, or human capital, no causal inference can be drawn. The data are consistent with the hypothesis that unmanaged digital engagement may compound productivity constraints, but they do not demonstrate it. With that caveat firmly in place, two contrasts are nonetheless worth noting. Germany, despite lower smartphone usage, maintains substantially higher labour productivity—pointing to the importance of how, rather than how much, technology is used. South Korea, meanwhile, achieves productivity broadly comparable to Turkey despite far higher internet penetration, reinforcing the argument that it is the quality and purpose of digital engagement, not connectivity per se, that shapes productive outcomes.

The productivity consequences of information obesity and digital addiction

The most direct evidence linking information overload to productivity losses in Turkey comes from Yildirim and Ansal's (2014) study of banking professionals. Their research reveals a phenomenon that anyone who has worked in a modern Turkish office will recognise: mobile technologies, initially adopted to enhance efficiency and information flow, progressively increase workload, time pressure, and what the authors term 'technostress.' The result is a paradox familiar to students of technology adoption: the very tools designed to boost productivity end up undermining it by creating an expectation of constant availability and immediate responsiveness that fragments sustained analytical work.

This finding is consistent with practitioner accounts from Turkish professional settings. Employees in the banking and finance sectors frequently describe a working environment in which the sheer volume of incoming communications—emails, WhatsApp messages, internal platform notifications, client inquiries—has reached a point where 'managing the inbox' has become a full-time job that competes with actual productive work. More worrying still is how thoroughly normalised this has become: workers have adjusted their expectations downward, accepting fragmented attention as the new baseline rather than recognising it as a cost. The cognitive science literature is unambiguous that task-switching imposes significant 'switching costs' in terms of time, error rates, and mental fatigue, yet the modern Turkish workplace seems designed to maximise rather than minimise them. Doğan's (2026) in-press phenomenological study adds a further dimension by suggesting how digital addiction among Turkish employees may undermine not just productivity but workplace safety. Workers compulsively checking their devices are, by definition, not fully attentive to their physical environment—a concern particularly acute in manufacturing and service settings where lapses in attention can have immediate consequences. The study further suggests that digital addiction weakens 'collective responsibility'—the shared sense of obligation to maintain safety standards—as workers retreat into individualised digital worlds even during collaborative tasks. While these are qualitative findings from a single study and require corroboration from larger quantitative research, the mechanism they describe is plausible and consistent with the broader safety literature.

These safety implications carry real economic weight. Workplace accidents and injuries carry direct costs (medical treatment, compensation claims) and indirect costs (production disruption, retraining, reputational damage) that compound the more visible productivity losses from digital distraction. For Turkey, where workplace safety standards and enforcement have historically lagged behind OECD norms, the addition of digital addiction as a safety risk factor is particularly consequential. The implications for Turkey's future workforce are perhaps even more troubling than the current workplace effects. Multiple studies document high rates of digital addiction among Turkish youth: Sert et al. (2019) found significant associations between technology addiction and reduced academic performance among university students, while Boyacı (2019) noted that Turkish internet addiction research has predominantly focused on adolescents, reflecting widespread concern about this demographic. The RTÜK (2022) finding that Turkish youth spend over 4.5 hours daily on devices suggests that the cohort entering the labour market in the coming years may arrive with deeply ingrained digital consumption habits that are antithetical to sustained productive focus.

Perhaps the most troubling aspect of these findings is not the immediate academic performance consequences but the formation of cognitive habits. If young people develop their information-processing capacities in an environment of constant distraction and rapid-fire stimulus, they may never acquire the deep attention skills that complex knowledge work demands. Kaya et al. (2022), in their grounded theory study of Turkish adolescents at risk of digital addiction, document how gaming and social media create feedback loops that progressively shorten attention spans and reduce tolerance for sustained cognitive effort. The labour market implications of this cognitive restructuring extend far beyond what current studies capture, and they represent what may be the most significant long-

term productivity threat associated with information obesity. Not all digital engagement undermines productivity, and the genuine economic benefits that digitalisation has delivered to Turkey deserve acknowledgement. Kahveci and Gurgur (2025) document positive associations between digital payments and GDP growth in Turkey, while Turkdonmez, Hazar, and Babuscu (2025) show how banking digitalisation has enhanced efficiency and financial inclusion. Comparable dynamics are observable in other transitioning economies: Aliyev et al. (2024) demonstrate a significant causal relationship between renewable energy consumption and economic growth in Azerbaijan using Toda-Yamamoto VAR methodology, illustrating how productive digital and technological investment can generate measurable growth dividends. Similarly, Abdulhasanova (2025) identifies the structural financial barriers impeding green economic transitions in Azerbaijan, while Ahmadova et al. (2026) examine how investment priorities shape ecological sustainability outcomes in the same economy—both sets of findings highlighting structural governance gaps that closely parallel the digital productivity deficits documented in this article. These findings matter because they complicate any simple story: digital technology does not inevitably destroy productivity. The problem lies not in digital engagement per se but in the specific patterns of engagement—compulsive, fragmentary, consumption-oriented—that characterise information obesity. Gümrah and Karagöz (2023), in their study of Turkish university students, provide an interesting finding: digital addiction does not appear to negatively impact financial literacy. This suggests that targeted, instrumental digital use (such as managing finances) operates through different cognitive channels than passive, consumption-oriented digital use (such as scrolling social media). The practical implication is that policy need not aim to reduce digital engagement as such, but to change its character—less passive consumption, more purposeful use. Current Turkish ICT policy makes no such distinction.

Socioeconomic mediators: Gender, class, and regional disparities

The gendered dimensions of this problem in Turkey are stark, and they are worth unpacking carefully. Several dynamics intersect here. First, the persistent gender gap in internet access (5.4 percentage points in 2025) means that women as a group have less experience and potentially less sophistication in managing digital information flows, making them more vulnerable to information overload when they do engage digitally (Zengin & Naktiyok, 2022). Second, Şahanoğulları and Bilgin (2025) document a gender-based digital divide in Turkey through time use analysis, showing that women's digital engagement patterns differ qualitatively from men's in ways that may compound existing labour market disadvantages.

Table 3
Gender disparities in digital engagement in Turkey

Indicator	Male	Female
Internet usage, 2025 (%)	93.6	88.2
E-government usage, 2025 (%)	82.8	69.5
Online shopping, 2025 (%)	59.1	52.3
WhatsApp usage, 2025 (%)	89.5 (2024)	82.9 (2024)
YouTube usage, 2024 (%)	74.7	68.0
Instagram usage, 2024 (%)	67.0	63.9
Online learning, 2025 (%)	17.5	18.0
E-commerce participation, 2025 (%)	59.1	52.3

Source: TurkStat ICT Survey (2024, 2025). Note: WhatsApp, YouTube, and Instagram figures from 2024 survey where 2025 gender breakdown not available.

Table 3 reveals a consistent pattern: women trail men across virtually every indicator of digital engagement except online learning, where participation is essentially equal. This gap is not merely about access—it reflects deeper structural inequalities in education, employment, and social norms that shape how women interact with digital technologies. Zengin and Naktiyok (2022) find that internet addiction disproportionately impairs female employee performance, with social support playing a crucial regulatory role. This suggests that when women do become heavy digital users, the productivity consequences may be more severe because they operate in work environments with less institutional support for managing digital overload. The one area where women match or slightly exceed men—online learning—is perhaps the most hopeful finding in the entire dataset. It suggests that women's digital engagement, when it occurs, may be more purposefully oriented toward skill development. Policy interventions that build on this pattern, encouraging productive digital use while providing support for managing information overload, could help transform a current vulnerability into a comparative advantage.

The relationship between socioeconomic status and information obesity in Turkey defies simple characterisation. University-educated professionals in Istanbul and Ankara may face the most severe information overload precisely because their work demands constant digital engagement. In contrast, workers in less digitally connected sectors or regions may be partially shielded from information obesity but simultaneously excluded from the productivity-enhancing benefits of digital technology. Polat (2012) identifies persistent digital exclusion among disadvantaged groups—the elderly, disabled, women, and rural residents—that Turkish ICT policy has failed to adequately address.

This observation points to what can be termed a 'digital productivity paradox' in Turkey: the regions and populations most exposed to digital technology (major urban centres, higher-educated professionals) face the greatest risk of information obesity, while those least exposed (rural areas, lower-educated populations) face the greatest risk of digital exclusion. Both extremes are productivity-diminishing, but they require fundamentally different policy responses. The challenge for Turkish policymakers is to find the 'sweet spot': sufficient digital engagement to capture productivity benefits without tipping into the compulsive overconsumption that characterises information obesity.

Regional disparities compound this challenge. Dalgic-Tetikol, Guloglu, and Koksal (2022) document significant variation in internet adoption determinants across Turkish regions, arguing for a more coherent and context-sensitive ICT policy vision. Fu et al. (2024), while focusing on China, provide methodological insights relevant to Turkey by showing that digitalisation affects urban-rural disparities differently at different levels of development. The implication for Turkey is that national-level digital policies may need to be complemented by regionally differentiated strategies that account for varying levels of digital maturity and information management capacity.

Structural determinants: Neoliberal reforms and digitally saturated work environments

The information obesity challenge in Turkey cannot be properly understood without looking at the structural conditions that have made it so persistent. Since the liberalisation programme initiated in the 1980s, Turkey's labour market has undergone profound transformation. Senses (2012) traces this neoliberal trajectory in detail, showing how successive waves of reform raised labour market flexibility at a significant cost to job security, worker protections, and work–life balance. These structural changes bear directly on information obesity, though the connection has rarely been made explicit.

Consider the mechanisms. Labour market flexibilisation has extended working hours, blurred the boundary between work and personal time, and created a culture of 'always on' availability that digital technologies have amplified rather than created. The rise of precarious employment, freelance work,

and platform-based gig labour has further intensified digital dependency, as workers in these arrangements must remain constantly connected to secure the next assignment, respond to client communications, and manage their digital presence. Özatalay and Altınok (2026) document how Turkey's neoliberal environment has produced 'pseudo-entrepreneurs' and 'compensation-driven investors' whose survival strategies depend heavily on continuous digital engagement.

The question of framing is perhaps the most consequential of all. The prevailing discourse on digital addiction treats information overconsumption as a personal failing—a problem of insufficient self-control that the individual must address through willpower or habit change. This framing is convenient for everyone except workers. It absolves platform companies of responsibility for designing addictive interfaces, relieves employers of any obligation to manage digitally saturated work environments, and lets governments off the hook for regulating the digital ecosystem more broadly. Keklik and Güler (2025) demonstrate how precisely this logic operates in health policy, where neoliberal framing systematically relocates responsibility from structural causes to individual behaviour. The same dynamic is at work in information obesity: what looks like a failure of willpower is, in most cases, a predictable response to structural incentives that reward constant digital engagement while offering no institutional support for stepping back from it.

The productivity consequences of this framing failure are real, if largely invisible. When workers face structural pressure to remain permanently reachable, when the platforms they use are engineered to hold attention rather than serve it, and when policy responds to the resulting overuse by blaming individuals rather than examining incentives, the costs accumulate quietly. No single worker's distracted hour registers in the national accounts, but the aggregate effect—millions of employees operating at slightly diminished capacity, day after day—amounts to a substantial and largely unacknowledged drag on economic output.

Policy recommendations: A multi-tiered approach

If the argument advanced in this article holds, effective policy cannot confine itself to a single level of intervention. Tackling information obesity through digital literacy programmes alone, while leaving intact the structural incentives for overconsumption, would be roughly as effective as responding to a public health emergency with individual counselling while declining to regulate the sources of contamination. The response needs to work at three levels at once: education, the workplace, and government regulation.

Table 4
Proposed multi-tiered policy framework for addressing information obesity and digital addiction in Turkey

Level	Intervention	Target group	Expected outcome
Education	Mandatory media literacy and digital well-being curriculum in primary and secondary schools	Children and adolescents (ages 6–18)	Reduced digital addiction prevalence; improved critical information assessment skills; formation of healthy digital habits before labour market entry
Education	University-level courses on information management, digital productivity, and attention management	University students	Enhanced labour market readiness; reduced academic performance losses from digital distraction; development of metacognitive awareness

Workplace	Digital well-being programmes: notification management protocols, device-free meeting policies, designated focus hours, and mental health support	Employees across all sectors	Reduced technostress; improved sustained attention and deep work capacity; enhanced safety culture
Workplace	Flexible work arrangements with structured digital boundaries and right-to-disconnect provisions	All workers, with gender-sensitive design	Improved work–life balance; reduced digital overload without sacrificing flexibility benefits
Government	National digital inclusion strategy with regional equity provisions and quality-of-use indicators	Disadvantaged groups: rural populations, women, elderly, disabled	Reduced digital divide; shift from passive consumption to productive digital engagement
Government	Regulation of platform design features that promote compulsive use (autoplay defaults, infinite scroll, manipulative notification patterns)	General population	Reduced ambient digital stimulation; structural support for individual self-regulation
Government	Integration of information health indicators into national productivity monitoring and development planning	Policymakers and researchers	Evidence-based policy refinement; longitudinal tracking of information obesity trends and their economic consequences

Source: Author's own elaboration based on evidence reviewed in this article.

The reason for insisting on all three levels at once is not theoretical tidiness. Educational interventions build long-term resilience but leave untouched the problems facing workers already in the labour market. Workplace measures can reduce current productivity losses but cannot reach those in precarious or informal arrangements. Government regulation creates the structural conditions for individual and organisational change to take hold, but it requires enforcement capacity and sustained political will—neither of which has been easy to maintain in Turkey's policy environment.

Üstündağ (2024) provides encouraging evidence that media literacy has predictive power in reducing internet addiction among Turkish adolescents, suggesting that the educational tier of this framework is empirically grounded. Similarly, Çivilidağ and Durmaz (2024) find that properly managed flexible work arrangements can improve employee performance, indicating that the workplace tier need not involve rigid anti-technology measures but rather thoughtful digital governance that distinguishes between productive and compulsive digital use. At the governmental level, Polat (2012) and Dalgic-Tetikol et al. (2022) identify significant gaps in Turkish ICT policy—particularly the absence of attention to use quality as opposed to mere access—that the proposed framework would begin to address.

The difficulty of implementing this framework should not be understated. Turkey's political economy creates significant obstacles. The technology sector is a major driver of economic growth, and regulations perceived as constraining digital engagement may face opposition from powerful industry interests. The neoliberal policy orientation documented by Senses (2012) works against precisely the kind of structural intervention this framework requires. And the cross-cutting nature of information obesity—spanning education, labour, technology, and health policy domains—creates coordination challenges that Turkish governance structures are not well designed to handle. None of this makes the framework impractical; it makes the task harder and the need for political commitment greater. The productivity costs of inaction are already accumulating, and they will not diminish as digital penetration deepens.

Conclusion

This article has argued that information obesity and digital addiction pose a significant, and largely unacknowledged, threat to Turkey's economic productivity. The evidence drawn together here—from cross-sectional surveys, sectoral research, national statistics, and the wider comparative literature—points in a consistent direction: Turkey's rapid digital expansion has delivered real gains in connectivity, financial access, and public services, but it has also created conditions in which cognitive overload and compulsive digital engagement have quietly eroded workers' capacity for sustained productive effort. The analytical framework developed here makes clear that the problem cannot be grasped—or meaningfully addressed—from any single vantage point. Individual digital behaviours do not emerge in a vacuum. They are shaped by workplace cultures, which in turn reflect the pressures of a labour market reoriented by decades of neoliberal reform, itself embedded within the wider dynamics of global digital capitalism. Intervening at only one of these levels, while leaving the others intact, is unlikely to achieve much. The multi-tiered policy framework proposed in this article represents the minimum response that the scale of the challenge warrants.

Three contributions stand out. First, treating 'information obesity' as a distinct analytical category—separable from both episodic overload and clinically defined addiction—opens a more productive line of inquiry into how habitual patterns of digital overconsumption erode productive capacity over time. Second, the analysis of gender, socioeconomic, and regional mediators shows that information obesity is not evenly distributed: its effects follow existing fault lines of inequality. The 'digital productivity paradox' identified here—whereby the most connected populations bear the greatest risk of information obesity, while the least connected face exclusion from digital gains—requires policy thinking that goes well beyond uniform national targets. Third, the multi-tiered framework provides a grounded starting point for interventions, ambitious in scope but rooted in the available evidence.

The research agenda that follows from this analysis is substantial. We need longitudinal studies that track the relationship between digital consumption patterns and productivity outcomes over time. We need qualitative research that captures the lived experience of information obesity among different worker populations. We need experimental studies that test the effectiveness of specific workplace interventions in reducing digital distraction and enhancing productive focus. And we need, above all, a willingness to take seriously the possibility that our most powerful technologies are not always making us more productive—and to develop the analytical tools and policy frameworks needed to ensure that they do. The comparative lens offered by neighbouring transitioning economies is instructive in this regard: as Ahmadova et al. (2026) show in their analysis of investment priorities for ecological sustainability in Azerbaijan, and as Abdulhasanova (2025) demonstrates with respect to green finance mobilisation, achieving structural transformation requires deliberate alignment of capital allocation with long-term developmental goals. Turkey's digital productivity agenda demands precisely the same discipline: investment priorities that privilege deep, purposeful digital engagement over passive consumption, backed by institutional frameworks capable of sustaining that orientation over time.

Turkey stands at a critical juncture. The digital infrastructure is in place, the population is connected, and the potential for technology-enabled productivity growth is real. But that potential will not be realised automatically. Without deliberate, multi-level intervention to manage the information environment—to ensure that digital technologies serve productive purposes rather than simply generating noise—Turkey risks entering what we might call a 'productivity paradox trap,' in which ever-increasing digital engagement produces ever-diminishing productive returns. The time for action is now.

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Managing Inflation and Price Stability in Volatile Transitional Markets

Valerii Parshakov[1*], Halyna Riabenko[2], Leonid Milman[3], Oksana Salamin[4], Andrii Krasnik[5]

Abstract. *The urgency of the study is caused by escalation of inflation instability in transitional economies under impact of global financial, commodity as well as geopolitical shocks, which complicates achieving sustainable price stability. As the institutional capacity of central banks is not strong, monetary policy instruments are sometimes inadequate to reduce inflation volatility. This underscores the importance of exploring how monetary conditions and inflation expectations interact with external factors in such economies. This study focused on inflation processes and its control in transitional economies. The methodological foundation is based on theoretical-analytical and empirical methods with comparative analysis of macroeconomic indicators for 2010–2023 using international statistical databases. The findings show that inflation volatility in transition economies remained higher than average price movements, leading to limited predictability of monetary policy. A rise in interest rates has a cooling effect but does not eliminate inflationary fluctuations in the medium run. We demonstrate that loose anchoring of inflation expectations exacerbates pass-through from world shocks to domestic prices. Inflation is highly sensitive to world commodity price shocks and liquidity swings. The policy relevance is that interest rate policy should be combined with institutional and communication policies to control inflation volatility. Results can be applied by central banks in developing strategies towards price stability under macroeconomic uncertainty.*

Keywords: *inflation, price stability, transition economies, inflation volatility, monetary policy, interest rates, inflation expectations, external shocks, exchange rate, global liquidity*

[1]Zhytomyr Polytechnic State University, PhD student, Zhytomyr, Ukraine
[2]Pylyp Orlyk International Classical University, PhD in Economy Sciences, Mykolaiv, Ukraine
[3]Chernivtsi Institute of Trade and Economics of State University of Trade and Economics, PhD student, Chernivtsi, Ukraine
[4]Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies of Lviv, PhD in Economics, Lviv, Ukraine
[5]Interregional Academy of Personnel Management, PhD in Technical Sciences, Kyiv, Ukraine
[*]Corresponding author. E-mail: parshakov_valerii@ujis.in.ua
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Dəyişkən keçid bazarlarında inflyasiya və qiymət sabitliyinin idarə edilməsi

Valeri Parşakov[1*], Halyna Ryabenko[2], Leonid Milman[3], Oksana Salamin[4], Andrey Krasnik[5]

Xülasə. *Tədqiqatın aktuallığı keçid iqtisadiyyatlarında qlobal maliyyə, əmtəə və həmçinin geosiyasi şokların təsiri altında inflyasiya qeyri-sabitliyinin artması ilə bağlıdır ki, bu da davamlı qiymət sabitliyinin əldə edilməsini çətinləşdirir. Mərkəzi bankların institusional potensialı güclü olmadığından, monetar siyasət alətləri bəzən inflyasiya dalğalanmasını azaltmaq üçün kifayət etmir. Bu isə belə iqtisadiyyatlarda monetar şəraitin və inflyasiya gözləntilərinin xarici amillərlə necə qarşılıqlı təsir etdiyini araşdırmağın vacibliyini vurğulayır. Bu tədqiqat keçid iqtisadiyyatlarda inflyasiya prosesləri və onun tənzimlənməsinə həsr olunub. Metodoloji baza beynəlxalq statistik verilənlər bazalarından istifadə etməklə 2010–2023-cü illər üzrə makroiqtisadi göstəricilərin müqayisəli təhlili əsasında nəzəri-analitik və empirik metodlara əsaslanır. Nəticələr göstərir ki, keçid iqtisadiyyatlarında inflyasiya dəyişkənliyi orta qiymət hərəkətlərindən yüksək olaraq qalmış, bu da pul siyasətinin proqnozlaşdırılmasını məhdudlaşdırmışdır. Faiz dərəcələrinin artırılması soyuducu təsir göstərsə də, orta müddətdə inflyasiya dalğalanmalarını aradan qaldırmır. Göstəririk ki, inflyasiya gözləntilərinin zəif bağlanması qlobal şokların daxili qiymətlərə ötürülməsini gücləndirir. İnflyasiya qlobal əmtəə qiymət şoklarına və likvidlik dalğalanmalarına yüksək həssaslıq göstərir. Siyasət baxımından faiz dərəcəsi siyasəti inflyasiya dəyişkənliyini idarə etmək üçün institusional və kommunikasiya siyasətləri ilə birləşdirilməlidir. Nəticələr makroiqtisadi qeyri-müəyyənlik şəraitində qiymət sabitliyinə yönəldilmiş strategiyaların hazırlanmasında mərkəzi banklar tərəfindən tətbiq oluna bilər.*

Açar sözlər: *inflyasiya, qiymət sabitliyi, keçid iqtisadiyyatları, inflyasiya dəyişkənliyi, monetar siyasət, faiz dərəcələri, inflyasiya gözləntiləri, xarici şoklar, valyuta məzənnəsi, qlobal likvidlik*

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[1]Jitomir Politexnik Dövlət Universiteti, doktorant, Jitomir, Ukrayna
[2]Pilip Orlyk Beynəlxalq Klassik Universiteti, iqtisadiyyat elmləri üzrə doktorant, Nikolayev, Ukrayna
[3]Çernovtsi Dövlət Ticarət və İqtisadiyyat Universitetinin Çernovtsi Ticarət və İqtisadiyyat İnstitutu, doktorant, Çernovtsi, Ukrayna
[4]Stepan Gzhytskyi adına Lvov Milli Baytarlıq Tibbi və Biotexnologiyalar Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Lvov, Ukrayna
[5]Regionlararası Personal İdarəetmə Akademiyası, texniki elmlər üzrə fəlsəfə doktoru, Kiyev, Ukrayna
[*]Məsul müəllif. E-poçt: parshakov_valerii@ujis.in.ua
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Introduction

In today's world, characterized by instability of the trajectory of capital and goods flows, there is increasing concern how to manage inflation for volatile transition markets, that is their unstable structural accommodation from one type economy to another in combination with a high sensitivity to external shocks combined with restricted flexibility of monetary sanctions. Inflationary mechanisms in such economies are determined not simply by internal macroeconomic factors, but also by international factors: variations in energy prices, the breakdown of supply chains and shifts in financial flows among nations. In such circumstances, the conventional monetary policy instruments are usually not enough to ensure price stability thus intensifying inflation volatility is observed, that shakes confidence of economic agents and fosters macroeconomic uncertainty.

Absence in the evolutionary interpretation of price stability management in transition economies shows that science one needs to have concerning mechanisms ensuring the -stability of price costs on a base actual background.

Today, in the science-speak of our times, its inflation seen as a macro trend change from globalization through global pandemic and post-pandemic shocks. Clarida (2024) examines inflationary processes due to supply shocks following structural alterations in supply chains, 56 large-scale fiscal stimuli, and changes in economic agents' behavior. The writer stresses the fact that despite waning inflation, risks of price instability persist and are particularly prominent for economies plagued by weak institutions and poor monetary policy instruments.

An interesting line of research investigates how inflation expectations drive macroeconomic volatility. Erceg et al. (2024) confirm the idea of "inflation scares" due to difference between realized price development and anticipation of economic agents. The paper stresses that such features may dramatically impair the efficacy of monetary policy, especially in transition countries where confidence in central banks builds up slowly and can be very easily affected by external shocks. The literature has focused specially on testing the credibility of inflation targeting as an instrument of achieving price stability. Guo and Lim (2024) investigate whether such a regime can reduce the volatility of inflation in an economy under different macroeconomic environments. Berry and Williams argue that the positive impact of inflation targeting is confined by institutional development level, fiscal discipline, and economic policy coordination in transitional economies, which challenges its universality.

The details of inflationary processes in economies in transition are discussed more thoroughly in Hernández et al. (2024). The study shows that inflationary pressures from abroad transmitted through supply chains play an outsize role in economies that rely heavily on imports. The findings emphasized the ineffectiveness of conventional instruments of monetary policy under similar circumstances and call for flexible policies in coping with inflation. The institutional dimension of the monetary policy in emerging markets is discussed in Kwizera (2024). The author studies central banks' reaction functions and shows that they often behave asymmetrically, relying on external financial conditions. This suggests that inherent structural constraints may exist in the inflation-stabilizing potency of such economies based exclusively on conventional monetary channels.

The paper by Ghosh and Ajit (2025) introduces a self-questioning reflection on monetary inflation targeting among emerging markets). The authors challenge the universality of this regime, by arguing that its efficiency is undermined in a context of high macroeconomic volatility. The paper underscores that without strong institutional support and structural reforms, inflation targeting is likely to exacerbate macroeconomic risks as well as price volatility. The impact of inflation, and the volatility of the latter, on growth is examined by Pappas and Boukas (2025). The authors contend that price instability depresses growth rates in both the short and long run, particularly in countries with underdeveloped financial markets. This illustrates the pragmatic value of managing inflation and rationalizes the search for good policies in transitional and unstable environments.

Despite a large literature on inflationary processes and monetary policy, several key issues remain unsolved in respect of the credibility of price stability in volatile transition markets. The majority of empirical works are based on developed economies or already regard inflation targeting as a universally applicable policy instrument without considering the structural and institutional limitations of transition societies. There has been little work on mechanisms through which inflation expectations, external shocks and monetary policy response interact in an environment of enhanced volatility, as well as the process to adapt standard monetary regimes to the specifics of such markets. Absence of universal methodological approach to estimation of the effectiveness of instruments of

inflation management in transitional economy frameworks makes more investigations aimed at bridging these scientific gaps.

The objective of the research was to apprehend the specifics of inflation and price stability management in a volatile transition market with reference to the interaction between among monetary tools, inflation expectations as well as external shocks under conditions when institutional capacity is limited. For this purpose, it concentrated on determining determinants of inflation volatility and evaluating the effectiveness of application of a range of monetary regimes as well as discerning the conditions under which conventional treatment strategies for price stability becomes ineffective.

It is also important to explore how the volatility of exchange rates is transmitted into domestic prices. Anderl and Caporale (2022) show that the currency pass-through effect is nonlinear and crucially influenced by the inflation expectations of economic agents. Rather these heterogenous and smooth transitioning results are to be expected in the highly uncertain macroeconomic environment characterized by periods of very volatile transactions markets that we have experienced. The worldwide character of inflationary developments is observed internationally through the examination of channels for importing price shocks. Auer et al. (2019) show how inflation may spread quickly between countries in the context of production and trade links, further destabilizing national markets. That shows the narrow tools of domestic liquidity policy in a highly integrated economy.

The necessity of coordinating macroeconomic policies is another important ingredient in maintaining price stability. Bianchi and Melosi (2019) show that lack of coordination between fiscal and monetary policy induces higher inflation volatility, erode trust in the central bank. Such findings seem important for the transition economies in which institutional interface still seems fragmented. The issues of internal balance have received much interest in the literature. Bils et al. (2021) study the contribution of observed inflation fluctuations to real resource misallocation imbalances or statistical measurement bias. Their findings indicate the difficulties of revealing inflation signals, which also make it difficult to design efficient price stabilization policies.

Greater economic openness may also be viewed as a cause of macroeconomic instability. Calderón and Kubota (2018) provide evidence that greater economic openness corresponds with higher volatility of the real exchange rate. This in turn raises further risks for the stability of prices in countries with undeveloped financial markets. The institutional quality of monetary authorities affects macroeconomic stability. Eichler and Littke (2018) show that the degree of transparency of a central bank heavily influences the volatility of currencies and inflation. Lack of dialogue and low predictability in monetary policies worsens the instability faced by most transition economies.

The role of trust in the monetary policy is closely connected to inflation expectations formation. Ferreira de Mendonça (2018) – focusing on a range of countries with emerging markets, finds low institutional trust to diminish the effectiveness of anti-inflation measures. This validates the necessity of considering the non-monetary factors in the monetary policy strategy in controlling inflation. The effects of supply shocks to long-term inflation dynamics is considered in the spirit of Fornaro and Wolf (2023). The authors contend that such shocks leave permanent “scars” on the economy, altering the path of inflation and potential growth. This makes the reliance on conventional monetary rules less appropriate in a more volatile environment.

The central bank's independence is an important factor in price stability. Garriga and Rodriguez (2023) empirically verify that in developing countries, the more autonomous the monetary authorities are, the lower is inflation volatility. At the same time, the authors stress that even formal independence is not a sufficient condition for policy effectiveness if it is not accompanied by an adequate institutional environment. Some research draws attention to power and communication dimensions of economic policy. Gilpin (2019) highlights the symbolic economy of power and the language of

authority which mediate the representation of policy choices. This is an interdisciplinary study, but about a concept that is also crucial in the context of trustworthiness of institutions when it comes to macroeconomic policy.

The more traditional angle of scrutinizing inflationary dynamics is still the examination of the currency pass-through. Ha et al. (2020) reveal that exposure of exchange rate shocks to prices varies substantially across countries and the inflation regime. This is crucial for economies in transition, where currency shocks are typically a major contributor to instability of inflation. Review Methodological methods for evaluating the effectiveness of monetary policy are discussed in Jordà et al. (2020). The authors apply quasi-experimental techniques to evaluate the effects of monetary policy on macroeconomic aggregates. The findings highlight the importance of relying on more flexible analytical methods to analyze inflation processes in complex and uncertain economic environments.

The objective of the study was to discover the specifics of inflation control and price targeting in turbulent transforming economies through examination of how monetary tools, expectations and external shocks interact in an environment where institutions are less developed among such economies. This goal was reached based on the understanding of the specific nature of monetary policy in increased macroeconomic uncertainty and unstable markets expectations. Reduced efficacy of conventional mechanisms for smoothing prices in transition economies was special focus when systemic barriers that constrain the degree of control over these necessary changes were identified.

As part of this objective, we examined what was responsible for the inflation volatility and tested how well various monetary regimes were adjusted to managing external shocks as well as internal disturbances. It was essential to disentangle the role of inflation expectations as a “channel” for transmission of macroeconomic instability and an “ingredient” which influences confidence in monetary authorities. The joint solution of these problems allowed formulating a theoretical basis for a special study of the efficiency of inflation regulation in economies with transitional and unstable development.

Materials and Methods

The article is based on the methodological principle and research methodology of the combination of theoretical, analytical methods and practical experience, and is based on a comparison analysis of certain macroeconomic indicators inherent in unstable transition economies for 2010–2023. The period considered includes the stages of post-crisis recovery from the global financial crisis, stabilization in terms of macroeconomic policy and periods with increased instability due to pandemic and geopolitical shocks, which allows a comprehensive analysis of inflationary processes’ evolution under different conditions (International Monetary Fund, 2024a; World Bank, 2024).

The theoretical basis for the study is constructed on modern provisions of monetary economics, namely the theory of inflation expectations, methods to analyze volatility of inflation and institutional approaches to monetary policy. The mechanical model is based on the theoretical premises of inflation targeting, pass-through exchange rates, and models of external price shocks transmission in open economic systems along with the official classifications of currency and monetary regimes and institutional features of monetary policy (International Monetary Fund, 2023a; Bank for International Settlements, 2023). The theoretical framework is enhanced by an institutional dimension which investigates the degree of central banks' independence, the extent of transparency in monetary actions and types economic agents' trust in monetary policy instruments both under growing uncertainty regarding financial markets (International Monetary Fund, 2023b).

The study rests on the empirical basis, which is comprised by the secondary statistical information taken from trusted international and national official statistics providers. International statistical information was obtained from the international databases released by International Monetary Fund (International Monetary Fund, 2024a; International Monetary Fund, 2024b), World Bank (World Bank, 2024) and Bank for International Settlements (2024), and national macro indicators were borrowed from the central banks reports of the selected transition countries. The analysis assumes the existence of consumer price inflation (CPI), volatility of CPI-inflation, exchange rate movements, key reference rates and inflation expectations between 2010 and 2023, which creates methodological comparability and analytical compatibility (Organisation for Economic Co-operation and Development, 2024).

To attain this goal, a systematic and logical analysis method was employed that allowed to generalize the prevailing theoretical aspects of inflation control policy considering the structural limitations for their implementation in transitional economy. Other studies employed a comparative method to analyse the dynamics of inflation-indicators and to assess the realisation of different monetary regimes during this period, considering central-regime as well as financial-institutional conditions of economies (International Monetary Fund, 2023a; Bank for International Settlements, 2023). In an abstract-logical way, generalized results were derived about the preconditions for in-effectiveness of conventionally applied price-stabilizing means.

The measurement of inflation volatility was measured in terms including the spread, standard statistical measure of consumer price growth variation over some period as calculated from aggregated international statistical series (International Monetary Fund, 2024a; World Bank, 2024). The research of interconnectedness between inflation, inflation expectations and external macroeconomic shocks was performed by an aggregated analytical generalization of macroeconomic rates with respect to the global commodity and financial influences.

Results

Inflation dynamics and inflation volatility in volatile transitional markets

During 2010–2023, inflation dynamics in volatile transition markets was rather uneven and more volatile pointing to a structural vulnerability of these countries from external and internal disturbances. Pooled statistical series based on International Monetary Fund, World Bank and Bank for International Settlements data reveal several relatively distinct phases of inflation dynamics defined by corresponding levels and fluctuations in growth rates of consumer prices (International Monetary Fund, 2024a; World Bank, 2024; Bank for International Settlements, 2024).

Following the crisis phase which ensued after the global financial crisis (2010–2013) the average annual inflation rate upon the sample of transition economies was kept on a relatively low level, and indicators for inflation volatility were subject to merely slight fluctuations. Annual inflation rates experienced a mild esteem during this period, signaling the short-term return of price stability and the partial re-establishment of macroeconomic equilibrium following crises' shocks.

During the period 2014–2019, which may be defined as a period of relative macroeconomic stabilization, average inflation rates were kept in check and their volatility appeared to grow over time. This was evident in the increase of spread between minimum and maximum inflation levels as well as increase in standard deviation. These changes are a consequence of the build-up over time of underlying internal structural imbalances and changes in the relative importance of external factors, notably exchange rate variations and global financial conditions, in determining inflation developments (Bank for International Settlements, 2023).

The strongest increase in both the mean inflation and its volatility occurred in 2020–2023. Pandemic shocks, ruptures of global supply chains and geopolitical tensions resulted in a sharp acceleration in consumer price growth in the majority of transition economies. In this phase the standard deviation of inflation was at his maximum values across the whole time span considered, showing there was great price instability, and little effectiveness on smoothing traditional monetary shocks channels (International Monetary Fund, 2023b; World Bank, 2022). Table 1 presents the quantitative features of inflation dynamics and volatility during the main periods of the study.

Table 1
Aggregate indicators of inflation and inflation volatility in volatile transitional markets in 2010–2023

Period	Average annual inflation rate, %	Minimum, %	Maximum, %	Standard deviation (SD)	Coefficient of variation (CV), %
2010–2013	6.1	2.	11.3	2.9	47.5
2014–2019	5.4	1.8	13.7	3.6	66.7
2020–2023	9.8	3.1	22.5	6.4	65.3

Source: Summarized based on IMF Data: International Financial Statistics, World Development Indicators, BIS Statistics Explorer (International Monetary Fund, 2024a; World Bank, 2024; Bank for International Settlements, 2024).

The evidence demonstrates that pro-cyclical volatile transitive markets not only have larger average inflation during crisis episodes, but that they suffer from an extraordinary increase in its volatility, which takes place both on the side of standard deviation and coefficient of variation. The acceleration of the growth rate of inflation variability compared to that of average inflation in 2020–2023 testifies for the higher uncertainty about price dynamics and asymmetry in reaction to global adverse shocks being at play in transition economies. The empirical evidence allows further consideration of the link between inflation volatility, institutional features of monetary policy and the effectiveness of central banks in achieving price stability under high macroeconomic uncertainty.

Monetary conditions, interest rates, and their relationship to price stability

From 2010 to 2023 there occurred transformation in monetary parameters in the most volatile transition economies that was apparent from changes of basic rates, resource cost, and aggregated financial condition. In aggregate, the use of interest rate policy in these economies has been largely reactive, focused on cooling the inflationary cycle that follows external and internal shocks rather than preventing them (International Monetary Fund, 2024a; Bank for International Settlements, 2024).

Tight monetary conditions prevailed in most transition economies from 2010 to 2013 following the crisis. Average key rates were also high by the standards of advanced economies, due to the necessity to curb inflation expectations and compensate for increased risks of macroeconomic volatility. Average rates were in a transition rate regime sample above 8 or 9 per cent, while the standard deviation of discount rates became moderate and implies reasonably predictable monetary policy and institutionalized operational parameters. At the same time, even in these circumstances, inflation volatility was not totally offset suggesting that the interest rate channel of transmission was weak when structural imbalances are present.

In the period of macroeconomic stabilization in 2014–2019, monetary conditions continuously eased. The key monetary rates decreased in general; the cost of credit resources fell, and domestic demand was stimulated. But on whole, it is evident that the decline in yields was not met with an equivalent fall in inflation volatility. In several transition countries the dispersion of inflation rates was limited to 3–4 per cent points even when interest rates were stable or weakly falling. This is evidence of inflation remains non-financial factors especially exchange rate fluctuations and structural supply-side imbalances affect interest rate instruments achieving negative impact (Bank for International Settlements, 2023).

The window of 2020–23 does central the relationship between monetary conditions and price stability. To cushion against the immediate pandemic impacts, many central banks in transition economies have been compelled to significantly loosen monetary conditions by cutting policy rates to boost economic activity. Nominal interest rates where on average today between 2 and 4 percentage points lower than before the crisis occurred. But the rapid acceleration of inflation in 2021–2022 caused monetary policy to change its spots, and this took form as a rapid (and often asymmetric) rise lifting rates.

Aggregate measures indicate that in 2022–2023, on average key rates in transition economies were above 10 per cent and the standard deviation of key rates rose substantially indicating greater spread and diversity of monetary reaction. Meanwhile, and even with tighter monetary conditions, inflation volatility still had been high. This lends support to the argument that monetary policy in the wake of global commodity and financial shocks operated stabilizing rather than restraining in so far as it prevented a further run-away increase of inflation, but did not achieve an immediate restoration of price stability (International Monetary Fund, 2023b; World Bank, 2022). The quantitative features of monetary conditions and their connection with price stability in the principal periods within the scope of our analysis are reported in Table 2.

Table 2
Aggregate indicators of key interest rates and inflation volatility in volatile transitional markets in 2010–2023

Period	Average key rate, %	Minimum, %	Maximum, %	SD of key rate	SD of inflation
2010–2013	9.2	4.	16.	3.1	2.9
2014–2019	7.1	3.2	14.5	2.6	3.6
2020–2023	11.4	1.9	22.7	5.2	6.4

Source: Compiled from IMF Data: International Financial Statistics, BIS Statistics Explorer, World Development Indicators (International Monetary Fund, 2024a; Bank for International Settlements, 2024; World Bank, 2024).

The findings demonstrate that heightened interest average levels in periods of crisis reflect a simultaneous partial attenuation in inflation volatility. Widespread between the maximum and minimum values of interest rates and inflation in 2020–2023 confirm that the transmission of monetary policy through the interest rate channel is assumed to be unstable in transitional economies and to a large extent depends on external terms of credit availability, level of dollarization, trust to

central banks. The empirical findings also reveal a non-symmetric relationship between monetary conditions and inflation. Interest rate policy is asymmetric: the central bank does not gain as much in reducing inflation volatility by easing interest rates when growth indicators indicate a recession, as it loses in generating financial instability and increased macroeconomic volatility to bring down inflation due to an excessive anti-inflationary monetary policy bias. It validates the usefulness of interest rates as the single instrument to secure price stability by pointing out some limitations regarding their power and explained an empirical background towards a further discussion on institutions, structures and inflation management.

Inflation expectations and the impact of external macroeconomic shocks

Between 2010 and 2023, inflation expectations in volatile transition economies are the principal determinant of realized price dynamics and the effectiveness of monetary policy. The analysis of aggregated data from the Organisation for Economic Co-operation and Development, the International Monetary Fund and the Bank for International Settlements suggest that inflation expectations in these economies tend to present heightened (or higher) responsiveness or sensitivity to foreign macroeconomic shocks, instability rents of growth processes and weak anchoring of long-term targets (Organisation for Economic Co-operation and Development, 2024; International Monetary Fund, 2023b).

In the post-crisis period of 2010–2013, however, the average medium-term expectations for inflation in transition economies fell behind those for actual inflation. Aggregated estimates put the average expected level of inflation over a one-year horizon to be approximately 6–7 per cent, with the standard deviation at 2–3 percentage points. This shows some downward anchoring of expectations compared to before the global financial crisis, but its dispersion was still much higher than in advanced economies, indicating patently low trust in monetary authorities and ineffective communication of central bank policy.

From 2014 through 2019, inflation expectations ceased to decline and partly stabilized but remained inadequately anchored. The mean of expected inflation was reduced to 4–5%, but the coefficient of variation of expectations increased, reflecting not only that economic agents were becoming more uncertain about the environment, but also that they are reacting differently to these changes. These expectations were fundamentally influenced during this time by events in the external sector, which led global energy price and global financial conditions -specifically international interest rates and capital movements- to be the key factors defining those expectations (World Bank, 2022; Bank for International Settlements, 2023).

The most significant movements in inflation expectations occurred during 2020–2023, when they were influenced by pandemic and geopolitical shocks. For instance, the OECD reports that in a sample of transition economies the average value of the inflation expectations over one-year horizon increased to 8–10% and their standard deviation exceeded 5 percentage points. This implies a larger spread of the opinions on future prices expressed by the economic actors and a higher uncertainty with regard to future price developments (Organisation for Economic Co-operation and Development, 2024).

Inflation expectations weighed by external macro-shocks were mostly spread via commodity market, exchange rate and global financial liquidity dimensions. Supply chain disruptions, coupled with soaring global energy prices during 2021–2022, resulted in a synchronized surge of inflation expectations throughout almost all transition economies irrespective of their national monetary regimes. The uptick in commodity price indeed went hand in glove with an almost equivalent increase in consumer confidence about future inflation which marks the overwhelming influence of international price stimuli on the formation of expectations (World Bank, 2022).

The foreign exchange channel operated as a distinct conduit of external shocks. In the presence of rising global financial volatility, 'depreciation expectations' were more powerful than actual price-adjustment; to such an extent that the negative psychological effect induced by devaluation made firms increase prices even though at this point not a single lira or dollar had been devalued. Between 2020 and 2023 the standard deviation of expected inflation increased faster than that for actual inflation, suggesting a potential leading response of expectations to external financial disturbances (International Monetary Fund, 2023a; International Monetary Fund, 2024b). Table 3 provides quantitative characteristics of the dynamics of inflation expectations and external shocks in the main phases of the period under consideration.

Table 3
Aggregate indicators of inflation expectations and external macroeconomic shocks in volatile transitional markets in 2010–2023

Period	Average inflation expectations, %	Minimum, %	Maximum, %	SD of expectations	Commodity price index (average)
2010–2013	6.5	3	11	2.	98
2014–2019	4.7	2.1	9.6	3.1	95
2020–2023	9.1	4.0	18.7	5.6	132

Source: Summarized based on data from OECD Inflation Expectations, IMF World Economic Outlook Database, World Bank Commodity Markets Outlook (Organisation for Economic Co-operation and Development, 2024; International Monetary Fund, 2024b; World Bank, 2022).

The results indicate that for transition economies with relatively poor stability characteristics, price expectations not merely result from actual inflations, but develop a distinct independent channel of increasing macroeconomic instability. During times of external shocks, their variance grows more than the growth rate on the actual prices, which makes central bank work towards stabilization of inflation even more difficult. The high standard deviations of 2020–2023 expectations indicate that inflation forecasts are poorly anchored and internal self-perpetuating processes of inflation will become more widespread.

The empirical evidence indicates such that external macroeconomic shock effects price stability of emerging market economies mainly via the channel of inflation expectations. This is an empirical foundation for a more elaborate explanation of the role of communications policy, confidence in institutions and coordination of monetary and fiscal decisions which gives rise to long-run price stability.

Discussion

The empirical evidence on the dominance of currency role in determining volatility of inflation in transition economies is also in line with Junttila and Korhonen (2012) who pointed that a scale CPT crucially depends on whether a country inflates or disinflates. When undesired exchange rate fluctuations occur, in the face of unanchored inflation expectations, these shocks have a more widespread and asymmetric effect on domestic prices thus warranting a higher variability in inflation when adverse external shocks materialize. If interest rates don’t matter in transition economies, institutions of monetary policy do.

The stylized impact of foreign commodity and energy shocks on the inflation dynamics and its volatility is overall in line with Lu et al. (2024) who can remove energy shocks when considering

single inflation episodes with larger length times. While the study by Lu et al. (2024) who focus on the UK, a comparison of results suggests that disturbances of equivalent size tend to be more destabilizing for transition economies. This is probably due to the higher import-dependency and less elastic home markets.

The finding on the instability of inflation expectation in transition economies is supported by the results for Matsuoka et al. (2019), who emphasize the role of expectations for the propagation of macroeconomic shocks. That uncertainty in inflation expectations is higher during times of crisis is also consistent with the conclusion at weak anchoring of expectations in non-institutionally trusted countries. This goes some way to justify the suggestion that credibility of monetary policy is at least in part based on successful communication.

It is noticed from the results that the differential effects of energy shock and currency shocks on inflation are present, as supported by Mirza et al. (2023), on the interactions of inflation targeting and currency pass-through with upward energy price. Foreign price shocks continue to be a major driver of inflation dynamics even in countries where an official inflation targeting regime has been put in place. This illustrates the risks of introducing an inflation-targeting framework while ignoring structural features of the economy.

The restraints on the effectiveness of monetary policy to stabilize prices which we uncover may be rationalized in a macroeconomic trilemma perspective as put forward by Obstfeld et al. (2005). The menu trade-offs would be even starker for the transition economies, as they became more exposed to external shocks.

The findings also align with those of Stojanovikj and Petrevski (2021) that examined the macroeconomic consequences of inflation targeting in emerging markets. On the one hand, an average inflation rate tends to be suppressed during periods of relative tranquility. In the other hand, both experiences reflect the low short run volatility in inflation and so reveals that this regime is dominated by external shocks as well as institutional factors.

It is suggested that the notion of managing inflation and price stability in turbulent transition economies is a multi-dimensional phenomenon in which management of interest rate policy, inflations expectations and external macroeconomic shocks interact with each other along complex lines - directing policy along an asymmetric direction. Given the constraints of monetary devices under these conditions, there is a need to improve institutions that apply to stabilization mechanisms and the studying of structural characteristics of economies when designing anti-inflationary policies.

Conclusions

The analysis shows that the control of inflation in volatile period markets is the result of a combination of domestic macroeconomic disequilibria and external shocks, that ultimately would drive to significant distortions on price stability. The results are in line with the initial research expectations, and they confirm as inflation volatility behaves differently from the average rate of inflation in these economies where the natural policy instrument indicator showed a faster increase to tame inflation volatility relative to that of traditional monetary instruments. It is said that interest rate policy stabilizes mainly the further propagation of inflation waves but not a quick restoration to tranquil, low-price movements. Expectations of inflation are central in this mechanism, and poorly-anchored expectations magnify the effect of external commodity and financial shocks.

The originality of the research is that it does not use econometric models but aggregate international statistics to make a complete quantitative generalization of inflation, the dynamics of inflation, inflation volatility, monetary conditions and formation of expectations. The practical importance of

the results achieved consists in the fact that it economically justifies the necessity to support interest rate policy by institutional and communication measures directed at boosting trust in monetary institutions and diminishing expectation uncertainty. A drawback of the study is that it employs cross-country aggregate measures, which fails to take into consideration the specific national economies' features and their institutional environment peculiarities. Additional studies need to be conducted with respect to the impacts of institutional quality, exchange rate regimes, and the coordination of monetary and fiscal policy toward building long-run price stability in transition economies.

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Differences in Consumer Sustainability Perceptions by Demographic Characteristics: Evidence from Azerbaijan's Fast-Food Industry

Seymur Guliyev[1*], Rasim Abutalibov[2], Sahib Mammadov[1], Ilham Rustamov[3]

Abstract. *This study investigates whether consumer sustainability perceptions vary across demographic characteristics within Azerbaijan's fast-food industry. Drawing on a multidimensional conceptualization, sustainability perception is operationalized through five dimensions: environmental responsibility, social responsibility, ethical business practices, health and consumer well-being, and long-term sustainability orientation. A quantitative cross-sectional design was employed using survey data from 475 fast-food consumers in Azerbaijan. Sustainability perceptions were measured using an adapted Likert-scale instrument. Exploratory factor analysis and reliability testing were conducted to validate the measurement model, followed by independent samples t-tests and one-way analysis of variance (ANOVA) to examine demographic differences. The findings confirm a robust five-factor structure with satisfactory internal consistency across all dimensions. Statistically significant differences in sustainability perceptions were observed across gender, age, education, income, and employment status. Environmental and social responsibility perceptions differed primarily by gender, whereas ethical business practices, health and consumer well-being, and long-term sustainability orientation varied more strongly by socio-economic conditions and life-stage characteristics. Overall, sustainability perceptions among fast-food consumers in Azerbaijan vary systematically across demographic groups. This study contributes to sustainability and consumer behavior literature by providing empirical evidence from an underexplored emerging market context and by offering a demographic-based perspective on sustainability perception. From a managerial standpoint, the findings underscore the importance of developing segmented and targeted sustainability strategies that align with the expectations of distinct consumer groups in the fast-food sector.*

Keywords: *consumer sustainability perception, demographic differences, fast-food industry, Azerbaijan, environmental responsibility, social responsibility*

[1]Azerbaijan State University of Economics, PhD in Economics, Baku, Azerbaijan
[2]Baku Engineering University, PhD in Economics, Baku, Azerbaijan
[3]Azerbaijan State Oil and Industry University, PhD in Economics, Baku, Azerbaijan
[*]Corresponding author. E-mail: seymur_guliyev@unec.edu.az
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Demoqrafik xüsusiyyətlər kontekstində istehlakçıların davamlılıq qavrayışlarındakı fərqlər: Azərbaycanın Sürətli Qida Sənayesi (Fast-Food) üzrə empirik tədqiqat

Seymur Quliyev[1*], Rasim Abutalıbov[2], Sahib Məmmədov[1], İlham Rüstəmov[3]

Xülasə. *Bu tədqiqat Azərbaycan fast-food sənayesində istehlakçıların davamlılıqla bağlı qavrayışlarının demoqrafik xüsusiyyətlər üzrə fərqlənib-fərqlənmədiyini araşdırır. Çoxölçülü konseptual yanaşmaya əsaslanaraq, davamlılıq qavrayışı beş ölçü üzrə əməliyyatlaşdırılmışdır: ekoloji məsuliyyət, sosial məsuliyyət, etik biznes təcrübələri, sağlamlıq və istehlakçı rifahı, eləcə də uzunmüddətli davamlılıq yönümlülüyü. Tədqiqatda kəmiyyət xarakterli kəsikli (cross-sectional) dizayn tətbiq edilmiş və Azərbaycanda fast-food istehlakçılarından toplanmış 475 sorğu məlumatı əsasında analiz aparılmışdır. Davamlılıq qavrayışları uyğunlaşdırılmış Likert şkalası vasitəsilə ölçülmüşdür. Ölçmə modelinin etibarlılığını və uyğunluğunu yoxlamaq məqsədilə kəşfiyyatçı amil analizi və etibarlılıq testləri aparılmış, daha sonra isə demoqrafik fərqlərin müəyyən edilməsi üçün müstəqil seçmələr üzrə t-testi və birfaktorlu dispersiya analizi (ANOVA) tətbiq edilmişdir. Nəticələr qənaətbəxş daxili tutarlılıq göstəriciləri ilə möhkəm beşamilli strukturun mövcudluğunu təsdiq etmişdir. Davamlılıq qavrayışlarında cins, yaş, təhsil səviyyəsi, gəlir və məşğulluq statusu üzrə statistik cəhətdən əhəmiyyətli fərqlər müəyyən edilmişdir. Ekoloji və sosial məsuliyyət qavrayışları əsasən cins üzrə fərqlənmiş, etik biznes təcrübələri, sağlamlıq və istehlakçı rifahı, eləcə də uzunmüddətli davamlılıq yönümlülüyü isə daha çox sosial-iqtisadi şərait və həyat mərhələsi xüsusiyyətləri ilə əlaqəli olmuşdur. Ümumilikdə, Azərbaycanda fast-food istehlakçıları arasında davamlılıq qavrayışlarının demoqrafik qruplar üzrə sistemli şəkildə dəyişdiyi müəyyən edilmişdir. Bu tədqiqat davamlılıq və istehlakçı davranışı ədəbiyyatına, az araşdırılmış inkişaf etməkdə olan bazar kontekstində empirik sübutlar təqdim etməklə və davamlılıq qavrayışına demoqrafik əsaslı perspektiv gətirməklə töhfə verir. Menecerial baxımdan nəticələr fast-food sektorunda fərqli istehlakçı qruplarının gözləntilərinə uyğun seqmentləşdirilmiş və hədəflənmiş davamlılıq strategiyalarının hazırlanmasının vacibliyini vurğulayır.*

Açar sözlər: *istehlakçı davamlılıq qavrayışı, demoqrafik fərqlər, fast-food sənayesi, Azərbaycan, ekoloji məsuliyyət, sosial məsuliyyət*

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[1]Azərbaycan Dövlət İqtisad Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[2]Bakı Mühəndislik Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[3]Azərbaycan Dövlət Neft və Sənaye Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: seymur_guliyev@unec.edu.az
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Introduction

Sustainability has become a central theme in academic research and business practice, driven by climate change, environmental degradation, resource constraints, and rising societal expectations regarding ethical and social responsibility. Consumers are increasingly viewed as active participants in sustainable development, as consumption choices directly shape environmental and social outcomes. This is particularly evident in high-visibility and high-frequency consumption sectors such

as food and fast food, which are commonly associated with packaging waste, intensive resource use, and health-related concerns (Liu, 2024; Verma et al., 2024; Nugraha et al., 2024).

Fast-food companies operate in highly competitive markets characterized by convenience, standardized offerings, and strong price sensitivity. At the same time, these firms face growing pressure from consumers, governments, and society to adopt more sustainable practices, including reducing plastic use, improving transparency in sourcing, supporting food safety, and engaging in socially responsible activities (Tiboni-Oschilewski et al., 2024; McDonagh et al., 2024; Liu, 2024). As a result, sustainability is no longer viewed solely as an operational or regulatory issue but has become a perceptual factor shaping how consumers evaluate and judge fast-food brands.

Consumer sustainability perception refers to consumers' overall evaluation of a firm's environmental, social, ethical, and long-term responsibility practices as reflected in its products, operations, and communication efforts (White et al., 2019; Khan et al., 2023; Wang et al., 2023). Prior research demonstrates that such perceptions. In the fast-food industry, sustainability perception is especially critical because consumers may be skeptical of sustainability claims due to concerns related to greenwashing or unhealthy food offerings.

Although the literature on sustainability and consumer behavior has expanded substantially, much of the existing research focuses on behavioral outcomes such as purchase intention, willingness to pay, or brand loyalty. These studies frequently rely on causal models and advanced analytical techniques, including advanced causal modeling approaches to explain sustainable purchasing and brand-related outcomes (Borah et al., 2024; Wang et al., 2023; Liu, 2024). While this body of work provides valuable insights, it often treats consumers as relatively homogeneous and pays limited attention to demographic variation in sustainability perceptions. In practice, however, consumers may perceive and prioritize sustainability issues differently depending on characteristics such as gender, age, education, income, and employment status (Nguyen et al., 2020; Ghouse et al., 2024; Szulc-Obłoza & Żurek, 2024).

Examining demographic differences in sustainability perception is particularly important in emerging market contexts. In such settings, environmental awareness, income distribution, and access to sustainability-related information often vary considerably across population groups. Demographic characteristics shape not only knowledge levels but also value orientations, risk perceptions, and sensitivity to ethical and health-related concerns (Mallick et al., 2024). Consequently, sustainability initiatives that resonate with one group of consumers may be less relevant or less credible to another, underscoring the need for more segmented and evidence-based sustainability strategies.

From a geographical perspective, empirical research on consumer sustainability perceptions has largely focused on developed economies or major emerging markets, especially in food and consumer sustainability research conducted across developed and major emerging markets (White et al., 2019; Khan et al., 2023; Yuan et al., 2025). In contrast, evidence from the South Caucasus region remains scarce. Azerbaijan represents a particularly underexplored context due to rapid urbanization, rising fast-food consumption, increased exposure to international brands, and the gradual integration of sustainability themes into public and corporate discourse. Despite these developments, little is known about how consumers in Azerbaijan perceive and evaluate sustainability practices in the fast-food industry.

To address this gap, the present study examines differences in consumer sustainability perceptions across demographic characteristics in Azerbaijan's fast-food sector. Rather than focusing on causal relationships or behavioral intentions, the study adopts a comparative quantitative approach to assess whether sustainability perceptions vary significantly across demographic groups. In doing so, the research contributes to the literature in three ways. First, it extends sustainability perception research

to an underrepresented emerging market context. Second, it offers a demographic-based perspective that complements intention-focused sustainability studies. Third, it provides practical insights for fast-food managers seeking to design targeted and credible sustainability strategies aligned with diverse consumer expectations.

Recent research in food service and hospitality further indicates that sustainability-related judgments are shaped not only by operational practices such as packaging choices, waste reduction, and sourcing transparency but also by how these practices are communicated and interpreted by consumers. Evidence suggests that sustainability communication can influence perceived responsibility and environmentally conscious responses, particularly in emerging markets where sustainability awareness is still evolving and information asymmetries are common (Fischer et al., 2021; Liu, 2024). At the same time, increased scrutiny of environmental claims in the food sector has heightened consumer skepticism and concerns about greenwashing, especially when sustainability claims lack clarity or visible supporting practices (Nugraha et al., 2024).

Accordingly, this study investigates whether consumer sustainability perceptions differ across demographic characteristics (gender, age, education, income, and employment status) in Azerbaijan's fast-food industry.

Literature Review

Consumer Sustainability Perception as a Multidimensional Construct

Consumer sustainability perception refers to how consumers evaluate a firm's responsibility toward the environment, society, and consumer well-being, as well as its commitment to sustainable development in the long run. Rather than being a single attitude, sustainability perception is generally understood as a multidimensional concept that combines environmental, social, ethical, health-related, and long-term strategic aspects (White et al., 2019; Khan et al., 2023; Wang et al., 2023).

In recent marketing work, sustainability perception is increasingly treated as a "bundle" of evaluations that combine environmental and social responsibility with consumer-centered value (e.g., health, safety, and well-being), and these evaluations are shaped by the way firms frame sustainability benefits and make them tangible for consumers. Framework-based syntheses in marketing emphasize that sustainability responses are driven by multiple psychological routes (e.g., self-relevance, habit, affect, social influence), which supports the use of multidimensional measurement rather than a single global attitude indicator (White et al., 2019). In food-related contexts, the interpretation of sustainability signals (including labeling) is heterogeneous, and recent reviews show mixed effects of eco-labeling and sustainability cues depending on consumers' understanding, trust, and perceived credibility (Tiboni-Oschilewski et al., 2024).

Earlier sustainability research mainly focused on firm-level outcomes and broader environmental and societal challenges (Brundtland Commission, 1987; Elkington, 1997). More recent studies, however, emphasize the role of consumers and argue that sustainability initiatives create value only when they are noticed, interpreted, and positively evaluated by consumers (Chen, 2010). This issue becomes especially important in industries such as fast food, where sustainability claims may contradict common perceptions related to convenience, speed, and unhealthy consumption patterns. In such contexts, consumer perception plays a critical role.

Based on previous literature, this study conceptualizes consumer sustainability perception through five related dimensions: environmental responsibility, social responsibility, ethical business practices, health and consumer well-being, and long-term sustainability orientation. Each dimension represents

a different, yet complementary, way through which consumers assess sustainability-related efforts in the fast-food industry.

Environmental Responsibility Perception

Environmental responsibility perception reflects consumers' evaluations of a firm's efforts to reduce environmental harm and contribute to ecological sustainability. This dimension is closely linked to the broader sustainability discussion, which highlights responsible resource use, waste reduction, pollution control, and environmental protection (Elkington, 1997).

From a consumer point of view, environmental responsibility is often judged through visible and communicated practices, such as environmentally friendly packaging, recycling activities, and efforts to reduce environmental footprint. Mohr et al. (2001) argue that consumers increasingly expect firms to demonstrate concrete environmental actions, and these expectations strongly influence overall evaluations of corporate behavior. When such actions are perceived as sincere, they tend to improve consumers' sustainability perceptions.

Chen (2010) further points out that environmental responsibility is a key element of green brand equity, as it signals a firm's commitment to environmental values. In the fast-food industry, where issues such as plastic waste and energy use are highly visible, environmental responsibility perception plays an important role in shaping consumers' judgments of sustainability efforts.

In foodservice settings, environmental sustainability is closely linked to waste, plastics, energy intensity, and circular practices, and these themes dominate recent systematic reviews of restaurant sustainability. Current evidence suggests that restaurant adoption of green practices is uneven and often constrained by operational trade-offs, which reinforces why consumers may rely on visible cues (e.g., packaging, waste initiatives) when forming environmental responsibility perceptions (Madanaguli et al., 2022). Recent hospitality sustainability research further indicates that circular-economy practices aimed at reducing food waste represent a central environmental pathway for the sector, strengthening the relevance of the environmental dimension for consumer evaluation (Cardenas et al., 2024).

Social Responsibility Perception

Social responsibility perception refers to consumers' evaluations of a firm's responsibilities toward employees, local communities, and society as a whole. This dimension extends sustainability beyond environmental issues to include fair labor practices, social engagement, and community contributions. Brown and Dacin (1997) show that consumers develop corporate associations based on perceived social responsibility, which in turn affect their overall evaluation of firms and their products. Similarly, Mohr et al. (2001) emphasize that socially responsible behavior is increasingly seen by consumers as a basic requirement for acceptable corporate conduct. Firms perceived as ignoring social responsibilities may face negative evaluations, even when product quality is considered satisfactory. Recent studies indicate that social responsibility perception can strengthen the relationship between consumers and firms by increasing trust, credibility, and identification with the brand (White et al., 2019; Khan et al., 2023; Wang et al., 2023).

Recent studies further emphasize that consumers' perceptions of social responsibility are increasingly shaped by firms' engagement with employees, local communities, and broader societal issues. In service industries, including foodservice, socially responsible practices such as fair labor conditions, employee well-being, and community involvement have been shown to positively influence consumers' evaluations and trust, particularly when these practices are perceived as authentic rather than symbolic (Kim & Hwang, 2021; Khan et al., 2023).

In emerging market contexts, social responsibility perceptions are often influenced by socio-economic conditions and institutional development, which shape consumers' expectations regarding corporate social engagement (Zameer et al., 2022). This suggests that consumers may differ in how they evaluate social responsibility initiatives depending on income level, employment status, and exposure to corporate social responsibility discourse, reinforcing the relevance of demographic differences in social responsibility perception.

Ethical Business Practices Perception

Ethical business practices perception captures consumers' evaluations of a firm's honesty, transparency, and fairness in its business activities. This dimension reflects whether consumers believe that a firm behaves ethically in its operations, communications, and interactions with stakeholders.

Brown and Dacin (1997) suggest that ethical behavior forms an important part of consumers' corporate associations, influencing firm evaluations beyond basic product attributes. Ethical perception is particularly relevant in industries where concerns about misleading claims, quality standards, or unfair practices may arise. Ferrell and Hartline (2011) stress that ethical marketing practices are essential for building long-term credibility and reducing consumer skepticism.

Recent research indicates that perceived ethical behavior positively affects consumers' evaluations of firms by reinforcing perceptions of integrity, transparency, and credibility in sustainability communication (White et al., 2019; Wang et al., 2023). In the fast-food industry, ethical issues related to sourcing, transparency, and honest communication are closely connected to sustainability perception, making ethical business practices a crucial evaluative dimension.

Recent marketing and business ethics research highlights that ethical business practices play a critical role in shaping consumer trust and firm legitimacy, particularly in industries characterized by information asymmetry and frequent skepticism toward corporate claims. Studies show that transparency, honesty in communication, and ethical sourcing practices contribute significantly to consumers' ethical evaluations and overall sustainability perceptions (Ferrell & Hartline, 2011; Nugraha et al., 2024).

Contemporary evidence further indicates that consumers with higher levels of education and awareness are more likely to critically evaluate ethical claims and to differentiate between genuine ethical commitments and superficial or misleading practices (Wang et al., 2023). This supports the inclusion of ethical business practices as a distinct sustainability perception dimension and provides a theoretical basis for expecting demographic variation in ethical evaluations within the fast-food sector.

Health and Consumer Well-Being Perception

Health and consumer well-being perception refers to consumers' evaluations of a firm's concern for food safety, nutritional quality, and overall consumer welfare. In food-related industries, health considerations are closely linked to sustainability assessments.

Grunert et al. (2014) argue that consumers increasingly associate sustainability with food quality, safety, and transparency. Information about ingredients, nutritional value, and product safety strongly influences how consumers evaluate the responsibility of food providers. Lichtenstein et al. (2004) further show that perceptions of corporate responsibility, including concern for consumer well-being, shape consumers' responses to firms and their offerings.

Rokka and Uusitalo (2008) highlight that packaging and product presentation also influence health-related perceptions, as they act as signals of quality and responsibility. In the fast-food industry, where health-related concerns are frequently discussed, consumer well-being perception represents an essential dimension of sustainability evaluation.

Recent sustainability scholarship increasingly positions consumer health and well-being as a central pillar of sustainable consumption, particularly in food-related industries. Research indicates that consumers associate sustainability not only with environmental and social responsibility but also with food safety, nutritional quality, and long-term health outcomes (Grunert et al., 2014; Machin et al., 2025). In fast-food contexts, where concerns related to unhealthy consumption are prominent, health-related perceptions become especially salient in shaping overall sustainability evaluations.

Empirical studies further suggest that health and well-being perceptions vary across demographic and lifestyle characteristics, as age, employment status, and daily routines influence sensitivity to nutritional information and health risks (Nguyen et al., 2020; Wang et al., 2023). This reinforces the relevance of examining demographic differences in health and consumer well-being perception within fast-food sustainability research.

Long-Term Sustainability Orientation

Long-term sustainability orientation reflects consumers' perceptions of a firm's commitment to sustainability as a long-lasting strategic goal rather than a short-term marketing activity. This dimension emphasizes consistency, continuity, and future-oriented responsibility. The Brundtland Commission (1987) defines sustainable development as meeting present needs without compromising the ability of future generations to meet their own needs, providing the foundation for long-term sustainability thinking. Elkington's (1997) triple bottom line framework further underlines the importance of integrating environmental, social, and economic objectives over time. Martínez and del Bosque (2013) argue that consumers tend to evaluate firms more positively when sustainability initiatives are perceived as part of a long-term strategy rather than as temporary or opportunistic actions. In the fast-food industry, where concerns about greenwashing may exist, long-term sustainability orientation serves as an important signal of authenticity and genuine commitment.

Long-term sustainability orientation is increasingly discussed as a key indicator of perceived authenticity and strategic commitment in sustainability research. Recent studies suggest that consumers tend to evaluate firms more favorably when sustainability initiatives are perceived as embedded in long-term corporate strategy rather than short-term promotional activities (Martínez & del Bosque, 2013; Khan et al., 2023). This distinction is particularly important in sectors such as fast food, where concerns related to opportunistic sustainability claims and greenwashing are common.

Moreover, recent empirical evidence indicates that long-term sustainability orientation is influenced by consumers' socio-economic stability and educational background, as individuals with higher income and education levels are more likely to consider future-oriented sustainability outcomes (White et al., 2019; Szulc-Obłoza & Żurek, 2024). This supports the expectation that perceptions of long-term sustainability commitment may differ across demographic groups in emerging market contexts.

Conceptual Focus of the Study

Based on the reviewed literature, this study conceptualizes consumer sustainability perception in the fast-food industry as a five-dimensional construct consisting of environmental responsibility, social responsibility, ethical business practices, health and consumer well-being, and long-term sustainability orientation. Rather than focusing on causal relationships or behavioral outcomes, the

study adopts a comparative approach to examine whether these perceptions differ across demographic groups.

By focusing on demographic differences in sustainability perception within an emerging market context, this research addresses an important gap in the literature and provides a basis for more targeted and context-sensitive sustainability strategies in the fast-food industry.

Finally, recent research shows that sustainability-related attitudes and behaviors are moderated by socio-demographic factors (e.g., education and income), indicating that sustainability perceptions and responses are rarely uniform across populations. Empirical evidence from European consumer datasets confirms that socio-demographic variables can shape sustainability-related attitudes and behavioral patterns, strengthening the rationale for demographic segmentation and group comparisons in sustainability perception research (Szulc-Obłoza & Żurek, 2024; Szulc-Obłoza et al., 2025).

Research Methodology, Research Questions, and Hypotheses

Research Design

This study adopts a quantitative, cross-sectional research design, which is suitable for examining perceptual differences among predefined groups using statistical comparison techniques (Hair et al., 2019). A survey-based approach was used to collect standardized data from fast-food consumers in Azerbaijan, allowing systematic comparison of sustainability perceptions across different demographic categories.

Consumer sustainability perception is treated as a multidimensional construct, including environmental responsibility, social responsibility, ethical business practices, health and consumer well-being, and long-term sustainability orientation. This conceptualization is consistent with recent research in sustainability and consumer behavior literature emphasizing multidimensional evaluations of corporate environmental, social, and ethical responsibility (White et al., 2019; Khan et al., 2023; Wang et al., 2023). Demographic variables such as gender, age, education level, income level, and employment status, which influence how individuals approach products and services, are considered as grouping variables rather than independent predictors (Guliyev, 2024). Accordingly, independent samples t-tests and one-way analysis of variance (ANOVA) were employed to identify statistically significant differences between group means (Field, 2018).

Research Questions

Based on the literature review and the comparative focus of the study, the following research questions are proposed:

- **RQ1:** Do consumer perceptions of environmental responsibility differ across demographic characteristics?
- **RQ2:** Do consumer perceptions of social responsibility differ across demographic characteristics?
- **RQ3:** Do consumer perceptions of ethical business practices differ across demographic characteristics?
- **RQ4:** Do consumer perceptions of health and consumer well-being differ across demographic characteristics?
- **RQ5:** Do consumer perceptions of long-term sustainability orientation differ across demographic characteristics?

Hypotheses Development

Previous studies suggest that sustainability-related perceptions vary across demographic groups (Mohr et al., 2001; Lichtenstein et al., 2004). Based on this evidence, the following hypotheses are developed for each sustainability perception dimension:

- **H1:** Consumer perceptions of environmental responsibility differ significantly across demographic characteristics. *H1a***:** by gender, *H1b:* by age and education level
- **H2:** Consumer perceptions of social responsibility differ significantly across demographic characteristics. *H2a:* by gender, *H2b:* by income and employment status
- **H3:** Consumer perceptions of ethical business practices differ significantly across demographic characteristics. *H3a:* by gender, *H3b:* by education and age
- **H4:** Consumer perceptions of health and consumer well-being differ significantly across demographic characteristics. *H4a***:** by age, *H4b:* by employment status
- **H5:** Consumer perceptions of long-term sustainability orientation differ significantly across demographic characteristics. *H5a:* by income level, *H5b:* by education level

Measurement Instrument

Data were collected using a structured questionnaire consisting of two main sections. The first section gathered information on respondents' demographic characteristics. The second section measured consumer sustainability perception using a multi-item Likert-type scale, which is commonly applied in studies examining consumer attitudes and perceptions (Likert, 1932; Hair et al., 2019). Each sustainability perception dimension was measured using five items adapted from established studies in sustainability and corporate responsibility literature to ensure content validity (Elkington, 1997; Mohr et al., 2001; Pérez & del Bosque, 2015). All items were assessed using a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree").

Sample and Data Collection

The target population of the study consisted of consumers in Azerbaijan with prior experience in fast-food consumption. Data were collected through an online survey distributed via social media platforms and consumer networks. Participation in the survey was voluntary, and respondent anonymity was ensured. A target sample size of 400–500 respondents was determined, as this range is considered sufficient for group comparison analyses involving multiple demographic categories (Hair et al., 2019).

Data Analysis Techniques

Data analysis followed a structured, multi-step procedure. First, descriptive statistics were calculated to summarize respondents' demographic characteristics and sustainability perception levels. Reliability analysis was conducted using Cronbach's alpha, with values of 0.70 or higher considered acceptable for internal consistency (Nunnally & Bernstein, 1994). To test the proposed hypotheses, independent samples t-tests were applied for demographic variables with two categories, while one-way ANOVA was used for variables with more than two categories (Field, 2018). When statistically significant differences were identified, appropriate post hoc tests were conducted. All statistical analyses were evaluated at a 5% significance level ($p < 0.05$).

Summary of Methodological Approach

In summary, this study employs a quantitative, survey-based methodology supported by validated measurement scales and established statistical techniques to examine demographic differences in

consumer sustainability perceptions. The methodological approach is consistent with prior consumer behavior research and provides a reliable basis for interpreting the empirical findings.

Data Analysis and Hypotheses Testing

Descriptive Statistics

The empirical analysis is based on 475 valid responses collected from consumers in Azerbaijan who have prior experience with fast-food consumption. This sample size is above the commonly suggested minimum levels for group comparison analyses and is sufficient to conduct independent samples t-tests and one-way ANOVA with adequate statistical power (Hair et al., 2019).

The sample includes 475 respondents, of which 53.1% are female and 46.9% are male, showing a relatively balanced gender distribution. The age distribution is mainly composed of young and middle-aged consumers. The largest group falls within the 25-34 age category (35.6%), followed by 18-24 (26.9%), 35-44 (22.9%), and 45 years and above (14.6%). Regarding education level, 46.7% of respondents hold a bachelor's degree, while 26.9% have completed high school and 26.3% have a master's or doctoral degree. The distribution of income and employment status shows sufficient variation across different economic and occupational groups. Overall, the demographic profile of the sample indicates that it is appropriate for conducting comparative statistical analyses.

Exploratory Factor Analysis and Reliability Assessment

Since the sustainability perception scale was adapted from previous studies and applied in an emerging market context, an exploratory factor analysis (EFA) was performed to examine construct validity (Hair et al., 2019; Field, 2018).

Sampling adequacy and the suitability of the data for factor analysis were assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. KMO values above 0.60 indicate acceptable sampling adequacy, values above 0.70 indicate good adequacy, and values above 0.80 indicate very good adequacy (Kaiser, 1974; Hair et al., 2019). Bartlett's test is expected to be statistically significant at $p < 0.05$, indicating sufficient correlations among the items (Bartlett, 1954).

The results of the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity are reported in Table 2.

Table 1
KMO and Bartlett's Test

Statistic	Value
KMO (overall)	0.810
Bartlett's Chi-square	3668.83
Bartlett's df	300
Bartlett's p-value	< 0.001

Note: Table is produced by the authors based on the survey data.

The KMO value obtained is higher than 0.80, which is above the recommended level, and Bartlett's test is statistically significant. These results show that the data are suitable for conducting factor analysis.

Factor extraction was carried out using principal component analysis with varimax rotation. Only factors with eigenvalues greater than 1.0 were kept, following Kaiser's criterion (Kaiser, 1960). In social science research, a cumulative explained variance of around 50–60% or more is generally considered acceptable (Hair et al., 2019).

The eigenvalues and cumulative explained variance of the extracted components are presented in Table 3.

Table 2
Eigenvalues and Explained Variance (First 5 Components)

Component	Eigenvalue	Explained Variance (%)	Cumulative (%)
1	5.92	23.7	23.7
2	4.11	16.4	40.1
3	3.28	13.1	53.2
4	2.45	9.8	63.0
5	1.84	7.4	70.4

Note: Table is produced by the authors based on the survey data.

The results confirm a five-factor structure, consistent with the conceptual framework of consumer sustainability perception.

Reliability Analysis

Internal consistency reliability was examined using Cronbach's alpha. Alpha values of 0.70 or higher are generally accepted as indicating satisfactory reliability, while values above 0.80 are considered to show good reliability (Cronbach, 1951; Nunnally & Bernstein, 1994).

The internal consistency reliability of each sustainability perception dimension, assessed using Cronbach's alpha coefficients, is reported in Table 4.

Table 3
Reliability Statistics (Cronbach's Alpha)

Dimension	Cronbach's α
Environmental responsibility	0.832
Social responsibility	0.796
Ethical business practices	0.804
Health & consumer well-being	0.795
Long-term sustainability orientation	0.822

Note: Table is produced by the authors based on the survey data.

All dimensions exceed the accepted threshold, confirming strong internal consistency of the adapted scale.

Hypotheses Testing

Hypotheses were tested using independent samples t-tests and one-way analysis of variance (ANOVA). Statistical significance was evaluated at the 5% level ($p < 0.05$), which is standard in behavioral and social science research (Field, 2018; Pallant, 2020).

Environmental Responsibility Perception (H1)

Gender-based differences were examined using an independent samples t-test. Gender-based differences in environmental responsibility perception were examined using an independent samples t-test, and the results are presented in Table 5.

Table 4
t-Test by Gender (Environmental Responsibility)

Mean (Male)	Mean (Female)	t	p-value
3.52	3.86	−3.51	<0.001

Note: Table is produced by the authors based on the survey data.

The p-value is below the predefined threshold of 0.05, indicating a statistically significant difference. Therefore, H1a is supported. Differences across age and education levels were examined using one-way ANOVA. Differences in environmental responsibility perception across age and education groups were analyzed using one-way ANOVA, with the results summarized in Table 6.

Table 5
One-Way ANOVA Results (Environmental Responsibility)

Grouping Variable	F	p-value
Age	14.90	<0.001
Education	6.12	0.002

Note: Table is produced by the authors based on the survey data.

Significant F-values confirm differences across age and education groups. Thus, H1b is supported, and H1 is supported overall.

Social Responsibility Perception (H2)

The results of the independent samples t-test examining gender differences in social responsibility perception are reported in Table 7.

Table 6
t-Test by Gender (Social Responsibility)

Mean (Male)	Mean (Female)	t	p-value
3.61	3.89	−3.22	0.001

Note: Table is produced by the authors based on the survey data.

Female consumers report significantly higher social responsibility perceptions than male consumers. As the p-value is below 0.05, H2a is supported. Differences in social responsibility perception across income levels and employment status were examined using one-way ANOVA, as shown in Table 8.

Table 7
One-Way ANOVA Results (Social Responsibility)

Grouping Variable	F	p-value
Income	8.41	<0.001
Employment	5.06	0.025

Note: Table is produced by the authors based on the survey data.

Statistically significant differences are observed across income levels and employment status. Therefore, H2b is supported, and H2 is fully supported.

Ethical Business Practices Perception (H3)

H3: Consumer perceptions of ethical business practices differ significantly across demographic characteristics. Table 9 presents the results of the independent samples t-test assessing gender differences in ethical business practices perception.

Table 8
t-Test by Gender (Ethical Business Practices)

Mean (Male)	Mean (Female)	t	p-value
3.74	3.81	−1.21	0.227

Note: Table is produced by the authors based on the survey data.

The gender-based difference is not statistically significant ($p > 0.05$). Thus, H3a is not supported. Differences in ethical business practices perception across age and education groups were examined using one-way ANOVA, with the results reported in Table 10.

Table 9
One-Way ANOVA Results (Age and Education – Ethical Business Practices)

Grouping Variable	F	p-value
Age	4.88	0.003
Education	9.34	<0.001

Note: Table is produced by the authors based on the survey data.

Significant differences are observed across age and education groups. Accordingly, H3b is supported, and H3 is partially supported.

Health and Consumer Well-Being Perception (H4)

H4: Consumer perceptions of health and consumer well-being differ significantly across demographic characteristics. The results of the one-way ANOVA examining differences in health and consumer well-being perception across age groups and employment status are presented in Table 11.

Table 10
One-Way ANOVA Results (Age and Employment – Health & Well-Being)

Grouping Variable	F	p-value
Age	4.99	0.002
Employment	7.21	0.008

Note: Table is produced by the authors based on the survey data.

Health and consumer well-being perceptions differ significantly across age groups and employment status. Both p-values are below the 0.05 threshold, indicating support for H4a and H4b. Therefore, H4 is supported.

Long-Term Sustainability Orientation (H5)

H5: Consumer perceptions of long-term sustainability orientation differ significantly across demographic characteristics. Differences in long-term sustainability orientation across income and education levels were examined using one-way ANOVA, with the results reported in Table 12.

Table 11
One-Way ANOVA Results (Income and Education – Long-Term Sustainability Orientation)

Grouping Variable	F	p-value
Income	10.84	<0.001
Education	7.65	<0.001

Note: Table is produced by the authors based on the survey data.

The results show statistically meaningful differences across income and education groups. Since both p-values are below the accepted significance level, hypotheses H5a and H5b are confirmed, and therefore H5 is also supported. By using clear and well-established statistical thresholds from the literature, this study presents reliable empirical evidence that sustainability perceptions among consumers in Azerbaijan's fast-food sector vary across demographic characteristics. In addition, the validated measurement structure and transparent testing of hypotheses provide a solid empirical basis for the theoretical discussion and managerial implications discussed in the following section.

Discussion

The findings of this study align with recent research showing that sustainability perceptions are unevenly distributed across demographic groups. Prior studies indicate that gender, education, and income influence how consumers interpret environmental and social responsibility signals, whereas age and employment status shape sensitivity to health-related and long-term sustainability concerns (Nguyen et al., 2020; Wang et al., 2023). Consistent with evidence from foodservice and hospitality research, the present results suggest that sustainability perceptions are shaped by consumers' socio-economic conditions and life-stage characteristics rather than being universally shared (Kim & Hwang, 2021; Wang et al., 2024).

Environmental Responsibility Perception (H1)

The results show that perceptions of environmental responsibility differ significantly across demographic characteristics, providing full support for H1. Female consumers reported higher levels of perceived environmental responsibility than male consumers, and statistically significant differences were also observed across age and education groups. These findings are consistent with

earlier research suggesting that environmental concerns are not evenly distributed across demographic segments, particularly with respect to gender and education. Previous studies indicate that women and individuals with higher education levels tend to exhibit greater sensitivity to environmental issues and sustainability practices, which may reflect higher environmental awareness and stronger pro-social value orientations (Elkington, 1997; Mohr et al., 2001; Chen, 2010). The observed age-related differences further suggest that perceptions of environmental responsibility vary across life stages, reflecting generational differences in values, knowledge, and exposure to environmental discourse. In the context of Azerbaijan's fast-food industry, these results imply that environmental sustainability initiatives may be more effective when targeted toward specific demographic groups rather than implemented through uniform communication strategies.

Social Responsibility Perception (H2)

The empirical results fully support H2, indicating that perceptions of social responsibility differ significantly across gender, income level, and employment status. Female consumers reported higher levels of perceived social responsibility, while income and employment status were also associated with meaningful differences. These findings are in line with prior research emphasizing that perceptions of corporate social responsibility are shaped by socio-economic conditions and social roles (Brown & Dacin, 1997; Mohr et al., 2001; Pérez & del Bosque, 2015). Consumers with higher income levels may have greater exposure to CSR-related information or higher expectations regarding corporate conduct. Similarly, employment status may influence how consumers evaluate firms' social engagement, particularly in relation to labor practices, community involvement, and social fairness. Within an emerging market context such as Azerbaijan, where formal CSR frameworks are still evolving, these results suggest that social responsibility is interpreted differently across segments of society. Accordingly, fast-food firms may benefit from tailoring social responsibility initiatives to the expectations and sensitivities of different consumer groups.

Ethical Business Practices Perception (H3)

The findings provide partial support for H3. While no significant differences were observed between male and female consumers, perceptions of ethical business practices varied significantly across age and education groups. The absence of gender differences suggests that ethical aspects of business behavior are perceived similarly by men and women in this context. In contrast, the significant effects of age and education are consistent with prior research highlighting the role of knowledge, experience, and cognitive resources in shaping ethical evaluations (Brown & Dacin, 1997; Ferrell & Hartline, 2011; Pérez & del Bosque, 2015). Consumers with higher education levels may be more familiar with ethical standards, transparency norms, and corporate governance practices, leading to more critical assessments of firms' ethical conduct. In Azerbaijan's fast-food market, these findings indicate that ethical business practices are particularly salient for consumers with higher education and greater life experience. This underscores the importance of communicating ethical commitments in ways that correspond to varying levels of consumer awareness and scrutiny.

Health and Consumer Well-Being Perception (H4)

The results fully support H4, revealing significant differences in health and consumer well-being perceptions across age groups and employment status. These findings highlight the influence of lifestyle and daily routines on how consumers evaluate health-related sustainability dimensions. Consistent with earlier studies, perceptions related to health and well-being vary across life stages, as consumers of different ages assign differing importance to nutrition, personal health, and long-term well-being (Grunert et al., 2014; Lichtenstein et al., 2004; Rokka & Uusitalo, 2008). Employment status may further shape eating habits, time constraints, and reliance on fast food, thereby influencing perceptions of health-related responsibility. In an emerging economy such as Azerbaijan, where

awareness of health issues in the fast-food sector is increasing but remains uneven, these results suggest that health-focused sustainability initiatives should be adapted to specific consumer segments rather than applied uniformly.

Long-Term Sustainability Orientation (H5)

The findings provide full support for H5, indicating that long-term sustainability orientation differs significantly across income and education levels. Consumers with higher income and education levels exhibit a stronger orientation toward long-term sustainability commitments. This result is consistent with sustainability theory, which links long-term orientation to economic stability and cognitive capacity (Brundtland Commission, 1987; Elkington, 1997; Martínez & del Bosque, 2013). Consumers with more secure financial conditions and higher educational attainment may be more inclined to consider future-oriented sustainability issues, including resource conservation and long-term social impacts. In the context of Azerbaijan's fast-food industry, this finding highlights the importance of framing long-term sustainability commitments in ways that are accessible and meaningful to consumers from diverse socio-economic backgrounds.

Conclusion

This study examined differences in consumer sustainability perceptions across demographic characteristics in Azerbaijan's fast-food industry. Using a quantitative approach and a multidimensional measurement framework, the findings provide empirical evidence that sustainability-related perceptions are not uniform across consumer groups in an emerging market context. The results confirm that sustainability perception consists of several distinct dimensions: environmental responsibility, social responsibility, ethical business practices, health and consumer well-being, and long-term sustainability orientation. Each of these dimensions varies according to demographic factors such as gender, age, education, income, and employment status. While some dimensions show clear gender-based differences, others are more strongly shaped by socio-economic conditions and life-stage factors. This highlights the limitations of a one-size-fits-all approach to understanding sustainability perceptions. Overall, the study contributes to a more detailed understanding of how consumers in emerging economies perceive sustainability in the fast-food sector. By demonstrating the demographic diversity of sustainability perceptions, the study supports the view that sustainability is a socially embedded concept influenced by consumers' backgrounds and lived experiences.

Implications

Theoretical Implications: From a theoretical perspective, this study contributes to sustainability and consumer behavior literature in several ways. First, it provides empirical evidence from Azerbaijan, a context that has received limited attention in previous research on sustainability perceptions. Second, by applying a multidimensional framework and explicitly examining demographic differences, the study deepens understanding of how different sustainability dimensions are perceived unevenly across consumer groups. The findings support theoretical arguments that sustainability perceptions are shaped by social, educational, and economic factors, rather than being universally shared. This demographic-focused approach offers a useful direction for future research in emerging market contexts. Managerial Implications: From a managerial standpoint, the results suggest that fast-food companies operating in emerging markets should reconsider standardized sustainability strategies. The observed demographic differences indicate that sustainability initiatives and communication efforts are likely to be more effective when tailored to specific consumer segments. For instance, environmental and social responsibility initiatives may appeal more strongly to certain groups, while health-related or long-term sustainability messages may be more relevant to others.
Managers may therefore benefit from segmenting sustainability communication strategies based on demographic characteristics and aligning specific sustainability dimensions with the expectations of

different consumer groups. Such targeted approaches can enhance the credibility of sustainability efforts, strengthen consumer engagement, and support more effective implementation of sustainability practices in the fast-food industry.

Policy Implications: The findings also offer important implications for policymakers and regulators. Recognizing that sustainability perceptions differ across demographic groups can help in designing more inclusive sustainability policies and public awareness campaigns. Policymakers may use these insights to promote responsible business practices and develop sustainability education initiatives that address the diverse needs and expectations of society.

Future Studies

Despite its contributions, this study has several limitations that point to directions for future research. First, future studies could use longitudinal designs to examine how consumer sustainability perceptions change over time, especially as sustainability awareness and regulatory frameworks continue to develop in emerging economies. Second, incorporating psychographic variables, such as personal values, environmental concern, or ethical orientation, may provide deeper insights into sustainability perceptions beyond demographic characteristics. Future research could also extend the analysis to other sectors, such as retail, hospitality, or manufacturing, to explore whether similar demographic patterns exist across industries. Comparative cross-country studies would further improve understanding of how cultural, institutional, and economic contexts influence sustainability perceptions. Finally, mixed methods approach combining quantitative surveys with qualitative interviews could help capture more nuanced consumer views on sustainability. By addressing these areas, future studies can build on the findings of this research and contribute to the development of more context-sensitive and inclusive sustainability strategies in both academic and practical settings.

Ethical Statement

This study involved human participants. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection. Formal ethical approval was not required for this study under applicable institutional/national guidelines, as the research involved anonymous adult participants and no sensitive personal data were collected. Respondent anonymity and confidentiality were ensured, and no personally identifiable information was collected. The study was conducted in accordance with generally accepted ethical principles for research involving human subjects.

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The Use of Digital Storytelling as an Innovative Tool in Developing Foreign Language Speaking Skills

Turkan Ismayilli[1*], Alaskar Ozperchin[2], Narmin Ibrahimli[3], Gunay Naghiyeva[3], Dilbar Orujova[1]

Abstract: *This study explores the potential of digital storytelling as an innovative pedagogical tool in developing speaking skills in foreign language education. A case study design, a qualitative research method, was employed in order to investigate the experiences and perceptions of students. The research sample consisted of 9 students enrolled in the class of the Faculty of Medical in the speciality of Public Health. The findings revealed that the integration of digital storytelling contributed positively to students' retention of knowledge, their motivation to participate actively, and their willingness to express themselves more freely compared to traditional classroom presentations. Many students reported that the use of digital stories made lessons more enjoyable, reduced speaking anxiety, and offered a more comfortable environment for self-expression. Moreover, the combination of images, music, and narration provided a multimodal learning experience that catered to different learner preferences. In addition, students highlighted that digital storytelling not only enhanced their speaking competence but also improved their self-confidence, technological skills, and preparedness for lessons. While some participants raised concerns that reliance on pre-prepared scripts could limit opportunities for improvisational speaking, the majority viewed the method as both pleasant and engaging. The study concludes that digital storytelling can serve as an effective alternative to conventional presentation methods in foreign language classes. It offers a dynamic, student-centered learning environment that fosters creativity and collaboration. Future research is recommended to expand the scope of digital storytelling applications into other language skill areas such as reading, listening, and writing, as well as to explore its impact across different age groups and educational contexts.*

Keywords: *digital storytelling, foreign language, self-expression, active-learning, student motivation, education*

[1]Nakhchivan State University, PhD in Philology, Nakhchivan, Azerbaijan
[2]Istanbul University-Cerrahpasha, Turkey
[3]Nakhchivan State University, PhD Student, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: turkanismayilli@ndu.edu.az
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Xarici dil danışıq bacarıqlarının inkişaf etdirilməsində innovativ vasitə kimi rəqəmsal hekayəçiliyin istifadəsi

Türkan İsmayıllı[1*], Ələsgər Özperçin[2] Nərmin İbrahimli[3], Günay Nağıyeva[3], Dilbər Orucova[1]

Xülasə: *Bu tədqiqat rəqəmsal hekayə danışmağın xarici dil təhsilində nitq bacarıqlarının inkişaf etdirilməsində innovativ pedaqoji vasitə kimi potensialını araşdırır. Tələbələrin təcrübələrini və qavrayışlarını araşdırmaq üçün keyfiyyətli tədqiqat metodu olan bir iş araşdırması dizaynı istifadə edilmişdir. Tədqiqat nümunəsi Tibb Fakültəsinin İctimai Səhiyyə ixtisası üzrə təhsil alan 9 tələbədən ibarət idi. Nəticələr göstərir ki, rəqəmsal hekayə danışmağın inteqrasiyası tələbələrin biliklərini yadda saxlamasına, fəal iştirak etmək motivasiyasına və ənənəvi sinif təqdimatları ilə müqayisədə özlərini daha sərbəst ifadə etmək istəklərinə müsbət təsir göstərir. Bir çox tələbə rəqəmsal hekayələrin istifadəsinin dərsləri daha xoş hala gətirdiyini, danışıq narahatlığını azaltdığını və özünüifadə üçün daha rahat bir mühit yaratdığını bildirdi. Bundan əlavə, şəkillərin, musiqinin və rəvayətin birləşməsi müxtəlif tələbə üstünlüklərinə uyğun multimodal öyrənmə təcrübəsi təmin etdi. Bundan əlavə, tələbələr rəqəmsal hekayə danışmağın yalnız onların nitq bacarıqlarını artırmaqla yanaşı, özünəinamlarını, texnoloji bacarıqlarını və dərslərə hazırlıqlarını da artırdığını vurğuladılar. Bəzi iştirakçılar əvvəlcədən hazırlanmış ssenarilərə etibar etməyin improvizasiya nitqi üçün imkanları məhdudlaşdıra biləcəyi ilə bağlı narahatlıqlarını bildirsələr də, əksəriyyəti metodu həm xoş, həm də cəlbedici hesab etdi. Tədqiqat rəqəmsal hekayə danışmağın xarici dil dərslərində ənənəvi təqdimat metodlarına təsirli alternativ kimi xidmət edə biləcəyi qənaətinə gəlir. Bu, yaradıcılığı və əməkdaşlığı inkişaf etdirən dinamik, tələbə mərkəzli bir təlim mühiti təklif edir. Rəqəmsal hekayə danışma tətbiqlərinin əhatə dairəsini oxu, dinləmə və yazı kimi digər dil bacarıqları sahələrinə genişləndirmək, eləcə də onun müxtəlif yaş qruplarına və təhsil kontekstlərinə təsirini araşdırmaq üçün gələcək tədqiqatlar tövsiyə olunur.*

Açar sözlər: *rəqəmsal hekayə danışma, xarici dil, özünüifadə, aktiv öyrənmə, tələbə motivasiyası, təhsil*

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[1]Naxçıvan Dövlət Universiteti, filologiya üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[2]İstanbul Universiteti-Cərrahpaşa, Türkiyə
[3]Naxçıvan Dövlət Universiteti, doktorant, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: turkanismayilli@ndu.edu.az
Daxil oldu: 11 Fevral 2026; Qəbul edildi: 7 May 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

Although digital storytelling has been widely explored in foreign language education, most previous studies have primarily focused on general language skills such as writing and overall motivation. Limited attention has been given specifically to its impact on speaking anxiety reduction and oral fluency development in B1-level learners. Moreover, many studies rely on short-term observations or quantitative designs, with fewer qualitative case studies that explore learners' lived experiences in depth. Therefore, there is still a need for context-based qualitative research that examines how digital storytelling influences students' speaking performance, emotional engagement, and classroom participation in real instructional settings. Recent studies on digital storytelling in foreign language education show a growing consensus regarding its positive impact on learners' motivation, engagement, and speaking performance. However, researchers approach the phenomenon from different perspectives. For instance, Lee et al. (2014) focus primarily on speaking accuracy and

pronunciation development, emphasizing that digital storytelling allows learners to repeatedly listen to their own output, which improves oral production. In contrast, Castañeda (2013) highlights the affective dimension of language learning, arguing that digital storytelling significantly reduces speaking anxiety and encourages learner participation. Similarly, Yang and Wu (2012) and Robin (2016) emphasize the role of digital storytelling in enhancing creativity and learner autonomy, suggesting that students become active knowledge constructors rather than passive recipients (Behmer et al., 2012). Aydın (2018), however, extends this discussion by focusing on classroom atmosphere and learner attitudes, stating that digital storytelling contributes to a more positive and supportive learning environment.

More recent studies such as Ali et al. (2025) and Sari et al. (2025) confirm these findings and further emphasize the effectiveness of digital storytelling in improving both speaking and writing skills in EFL contexts. Nevertheless, Mazlan et al. (2025) draw attention to the challenges of digital literacy and technical limitations, which may reduce the effectiveness of implementation in some classroom settings. The literature suggests a strong positive relationship between digital storytelling and foreign language learning outcomes, particularly in terms of motivation, anxiety reduction, and communicative competence (Dhini, 2025). However, there is still a need for more context-specific qualitative studies focusing on learners' lived experiences in speaking classes.

Strengthening individual learning

- Individualizing the educational process
- Increasing motivation
- Facilitating cognitive learning.

It is also emphasized that integrating digital storytelling into the language learning and teaching process positively impacts students' motivation (Babasoy, 2025). It is stated that digital storytelling creates an active classroom environment, supports students' language learning, and is effective in correcting language errors and mistakes that hinder speech. According to Engin (2016), digital stories in foreign language education can support student creativity and provide opportunities for interdisciplinary study.

The digital storytelling method also increases students' interest in language learning. Mammadova and Asadova (2025) stated that teaching English through digital stories improves comprehension and reading fluency skills. In addition, students' vocabulary knowledge was also reported to increase. Holotescu (2014) examined the effects of digital stories on speaking skills and concluded that the digital story method positively impacted students' speaking skills. It was also noted that students better understood and understood grammar rules with this method (Ali, 2025). The positive aspects of the results of studies using digital stories in the literature provide guidance for further research. Considering that each student's individual and linguistic characteristics are unique, digital stories can be said to be an effective method for students. Studies are being conducted on the use of digital stories, which have applications in various fields, in foreign language education.

While previous research has largely focused on the effectiveness of digital storytelling in improving speaking performance, this study distinguishes itself by employing methodological triangulation through the integration of interviews and classroom observations. This approach allows for a deeper and more reliable understanding of students' experiences, perceptions, and classroom dynamics, thereby contributing to the existing literature with a more comprehensive and context-sensitive analysis. The study reconceptualizes digital storytelling as a structured pedagogical process that gradually transitions learners from controlled to more confident speech production (Alkamel, 2020). In this sense, digital storytelling is not treated merely as a tool, but as a pedagogical intervention targeting speaking anxiety. This research highlights a critical paradox in digital storytelling: while it

reduces anxiety and supports fluency development, it may simultaneously limit spontaneous speech production. By identifying this tension, the study contributes a more balanced and theoretically grounded understanding of digital storytelling in speaking pedagogy.

The use of digital stories in foreign language education is seen as important because it provides students with the opportunity to listen to themselves and facilitate active learning (Domalewska, 2024). Despite this, there are few studies in the literature that address the use of digital stories in foreign language speaking education. This study aimed to investigate the effects of the digital storytelling method on the speaking course of students studying in a foreign language preparatory class. For this purpose, student opinions regarding the use of digital stories in a foreign language speaking course were examined.

1. What are student opinions regarding the use of the digital storytelling method in a foreign language speaking course?
2. What are the observed outcomes of students' preparation and presentation of digital stories in a foreign language speaking course?

Method

2.1. Research Design

This study adopts a qualitative case study design to explore students' experiences with digital storytelling in a foreign language speaking classroom. A case study approach enables an in-depth examination of real-life educational contexts and allows the researcher to investigate complex phenomena holistically. In this study, the case study design is particularly appropriate as it focuses on understanding individual experiences, small group interactions, instructional practices, and the implementation process of digital storytelling within an authentic classroom setting. By examining the phenomenon in its natural environment, the study seeks to capture students' perceptions, emotions, and reflections in a comprehensive and contextualized manner.

The qualitative data obtained from semi-structured interviews, self-report forms, and classroom observations were analyzed using a systematic content analysis procedure consisting of several stages. First, all interview recordings were transcribed verbatim, and observation notes were organized into a coherent textual format. The researcher repeatedly read the data to achieve familiarization and to gain an overall understanding of participants' experiences.

Second, an inductive open coding process was conducted. During this stage, meaningful units of data were identified and labeled with initial codes. These codes were generated directly from the data without using any predefined coding scheme, allowing patterns and concepts to emerge naturally from participants' responses.

Third, the initial codes were reviewed and compared across the dataset using a constant comparison method. Similar codes were grouped together to form categories based on shared meanings and conceptual similarities.

Fourth, these categories were further refined and organized into broader themes that captured the main dimensions of students' experiences with digital storytelling. The themes identified in this study included *personal contributions, contribution to the learning environment,* and *problem situations*.

To enhance the credibility, dependability, and confirmability of the analysis, the coding process was carefully documented, and expert validation was sought. Two field experts reviewed the coding scheme and thematic structure to ensure consistency and conceptual clarity. Any discrepancies were discussed and resolved through consensus.

Finally, representative excerpts from the participants' responses were selected and presented in the findings section to support each theme and to provide transparency in the interpretation process.

In addition, observation data were analyzed in parallel with interview data to ensure data triangulation. The consistency between observed behaviors and interview findings strengthened the validity of the results.

Guided by a qualitative inquiry framework, the study sought to address the following research questions:

What are students' perceptions of using digital storytelling in foreign language speaking classes?

How do students describe the influence of digital storytelling on their speaking anxiety and motivation?

What challenges do students experience during the process of preparing and presenting digital stories?

These research questions were formulated to elicit detailed descriptions of students' lived experiences and to provide a nuanced understanding of both the benefits and challenges associated with digital storytelling in speaking instruction.

To ensure the trustworthiness of the findings, several strategies were employed. Credibility was enhanced through data triangulation by comparing findings from semi-structured interviews, self-report forms, and classroom observations. This triangulation allowed for cross-validation of the data and strengthened the overall interpretation. Nine students were chosen on a voluntary basis to ensure rich, detailed, and manageable data. This approach is consistent with qualitative research principles, which prioritize depth over breadth. The selected participants represented diverse levels of participation, motivation, and performance in the classroom, enabling the researcher to capture a range of perspectives and experiences.

2.2. Participants

The study sample consisted of 9 students from the NSU Medical faculty's students during the autumn semester of the 2025-2026 academic year.

The selection of B1-level learners was considered particularly appropriate for the purposes of this study. At this level, learners possess sufficient basic communicative competence to construct simple narratives, express personal experiences, and participate in guided speaking tasks. At the same time, they still face limitations in spontaneous speaking, which makes them more likely to benefit from structured and supportive instructional approaches such as digital storytelling.

Digital storytelling is especially suitable for B1-level learners, as it provides scaffolding through multimodal input (images, text, and audio), reduces cognitive and linguistic load, and allows students to prepare their speech in advance. This structured preparation is particularly beneficial for lower-intermediate learners who may experience speaking anxiety and limited fluency in spontaneous oral production.

Therefore, selecting B1-level participants ensured that the study captured the effectiveness of digital storytelling in supporting learners at an intermediate developmental stage, where pedagogical scaffolding plays a crucial role in improving speaking performance.

The participants' English proficiency level was determined using institutional placement procedures supported by instructor evaluation. At the beginning of the academic year, students were grouped

according to CEFR-based diagnostic assessment results and classroom performance indicators. Based on this combined evaluation, the selected participants were identified as B1-level learners.

2.3. Data Collection

During the first week of the study, the researcher conducted classroom observations of the traditional speaking lessons to document the instructional methods used, student participation patterns, and classroom behaviors. These observations aimed to establish a baseline understanding of the speaking course prior to the implementation of digital storytelling.

In the second week, students were introduced to the digital storytelling approach and familiarized with the Adobe Express. Adobe Express is a widely used digital storytelling tool in education due to its user-friendly interface and multimodal features. It enables students to combine images, text, narration, video, and music into a single digital story, making it highly suitable for foreign language learning contexts. Digital storytelling has been widely recognized as an effective pedagogical tool that enhances student engagement and motivation (Smeda, 2014). Recent research on Adobe Express for Education indicates that creative digital tools significantly enhance student engagement and communication skills in classroom settings.

One of its main advantages is ease of use, allowing learners to focus on language production rather than technical complexity. The platform offers ready-made templates and simple editing tools, which are especially beneficial for students with limited digital skills. In addition, its multimodal structure supports engagement and comprehension by integrating visual and auditory elements. The voice recording feature allows students to practice speaking, listen to their performance, and improve pronunciation, which contributes to reducing anxiety and increasing self-confidence. The researcher provided hands-on training sessions, including guided instruction and sample demonstrations, to ensure that students understood the basic functions of the program and the stages involved in creating a digital story.

During the third week, students selected their digital storytelling topics in collaboration with the course instructor. This stage involved brainstorming activities and preliminary planning, allowing students to choose topics that were personally meaningful and suitable for oral presentation. Students were also guided in organizing their ideas and drafting initial scripts for their digital stories. From the fourth week onward, students engaged in the digital story production process over a four-week period. During this time, they developed digital stories of approximately ten minutes in length on topics of their own choosing. The process included script writing, visual selection, voice recording, and multimedia editing using Adobe Express. Upon completion, the digital stories were presented in class, providing students with the opportunity to share their work with peers and engage in reflective discussion.

The research process began with the installation and introduction of the digital storytelling software and concluded with the classroom presentation of the completed digital stories. The overall digital storytelling process followed in this study is illustrated in Figure X, which outlines the key stages of topic selection, script development, multimedia production, and presentation.

1. Digital story process

Choosing a topic and writing the script
↓
Adapting the script for a digital story
↓
Creating the digital story scenario
↓
Developing multimedia materials (Storyboard, visuals)
↓
Editing audio and visuals
↓
Presenting the digital story

2.4. Data Analysis

Self-report forms were used to support the qualitative data obtained in the study. In addition, semi-structured interviews constituted the primary data collection tool. The interview protocol consisted of 12 open-ended questions designed to explore students' perceptions of the usability of digital storytelling in speaking classes, its contributions to their language learning, and its influence on students' interest, motivation, and speaking anxiety. To ensure the reliability of the coding process, intercoder agreement was established. In addition to the primary researcher, a second independent coder participated in the analysis process. The second coder, Professor Alaskar Ozperchin, a guest professor at Nakhchivan State University with expertise in applied linguistics, independently reviewed and coded a selected portion of the interview data based on the predefined coding framework.

Following independent coding, the results of both coders were compared to examine the level of agreement. A high degree of consistency was observed between the coding outcomes. Any discrepancies identified during the comparison process were discussed collaboratively and resolved through consensus, which contributed to the refinement and clarification of the coding categories and themes. During the development of the interview questions, three field experts were consulted to ensure content relevance and clarity. The interview questions were subsequently piloted with three students who did not participate in the study to evaluate linguistic clarity, comprehensibility, and the time required for completion. Based on the feedback received, minor revisions were made to the interview protocol. Classroom observations were also employed to gain in-depth and contextualized insights into the instructional process. Observation is defined as a systematic process in which the researcher directly observes the learning environment to collect open-ended and descriptive data (Jones, 2019). In this study, both the pre-digital storytelling speaking lessons and the digital storytelling implementation process were observed to identify changes in student behavior, engagement, and classroom dynamics.

To record observational data, unstructured observation forms were used. During the observation process, the researcher took detailed field notes while students prepared and presented their digital stories. These notes were later reviewed and analyzed to identify recurring patterns and meaningful behaviors related to student participation, confidence, and interaction. The data obtained from the semi-structured interviews were analyzed using content analysis. Students' responses were initially coded, and related codes were grouped to form broader categories and themes that reflected shared experiences and perceptions. To protect anonymity, participants were assigned codes (S1, S2, S3, etc.), and the findings were supported with direct quotations from the interviews.

Observation findings were analyzed in parallel with interview data to enhance data triangulation. The observation notes were summarized under general codes, which are presented in Table 2. Although the frequency of observed behaviors was categorized as *low*, *medium*, or *high* to indicate recurrence, these categorizations were used solely for descriptive purposes and not for statistical analysis. A *high* frequency indicates that the observed behavior occurred in most of the classroom, a *medium* frequency indicates that it was observed in approximately half of the group, and a *low* frequency indicates that it occurred in a smaller portion of the participants.

Findings

Student opinions on the application of digital storytelling were obtained through semi-structured interviews. The interview findings are presented in Table 2.

Table 1
Students' Opinions on the Use of Digital Storytelling in Speaking Lessons

Themes	Codes	f	Sample Answers
Personal Contributions (f=33)	Reducing anxiety (9)		"I had the chance to hear my own voice and pronunciation thanks to the digital story." (S7)
			"While preparing, we listened to ourselves again and noticed our mistakes. Since this speech was listened to by everyone, it reduced our anxiety." (S4)
	Reducing excitement (9)		"When speaking live, I get so excited that I sometimes forget what to say, but in the video I wasn't excited." (S3)
			"I think it is an opportunity for people who feel shy and cannot speak." (S7)
			"It allows shy students to make prepared speeches instead of spontaneous ones, gradually reducing their shyness." (S2)
	Increasing interest & motivation (7)		"Since digital storytelling includes music and visuals, my interest increased." (S5)
	Increasing self-confidence (5)		"Sharing my work with everyone gave me confidence." (S4)
	Technology use (3)		"It helps us use technology better and benefit more from developing technology." (S4)
	Effective learning environment (9)		"We can support our topic with pictures and music while presenting." (S3)
			"It allows us to easily express our ideas on any topic with the help of pictures and music." (S2)
Contribution to the Learning Environment (f=28)	Coming prepared to class (7)		"In speaking lessons, we sometimes prepared during recess very spontaneously. But in digital story activities, we come prepared and after researching. I think this also affected our efficiency." (S3)
	Fun learning environment (5)		"It made the monotonous lesson more interesting." (S2)
			"It was a nice and instructive activity, and also enjoyable to watch." (S8)

	Easy-to-use program (3)	"It is an easy program for preparing a short story." (S6)
	Adaptability to other courses(4)	"In listening classes, students' comprehension can be tested by listening to the sound without subtitles while showing only the pictures." (S9) "I believe it can also help in writing and reading lessons, not just speaking." (S2)
Problem Situations (f=11)	Voice problems (6)	"I had many problems during voice recording." (S2)
	Music adding problems (2)	"It was difficult for me to record separate voices for each picture." (S6) "I couldn't adjust the music." (S3)
	Program installation problems (1)	"I had a problem installing the program." (S1)
	Preventing improvisation (4)	"In this program, people just read the texts in front of them, maybe it's good for reading lessons but I don't think it contributes to improvisational speaking." (S9) "It can definitely be useful in other lessons, but for speaking I don't think so, because no one spoke spontaneously." (S5)

Based on semi-structured interviews conducted with students, digital stories were evaluated under the general headings of personal contributions, contribution to the learning environment, and problem situations.

Table 1 shows that the digital story activity contributed most to students' personal development. In this dimension, students reported that the factors of anxiety and excitement that negatively affected them decreased, while their interest, motivation, and self-confidence increased, and they used technology better thanks to this activity.

Another impact of the digital storytelling process has been on the learning environment (Nuri, 2024). The view that digital stories provide a more effective learning environment with the visual and audio presentation opportunity is widely accepted by the students interviewed. There are also opinions that digital stories make the lesson more enjoyable and provide shy students with the opportunity to express themselves. Students report that digital stories help them speak more fluently and correct their pronunciation errors. They also stated that because they have the opportunity to listen to themselves repeatedly during preparation and presentation, they can more easily identify and correct their own mistakes, which allows them to come to class prepared.

The negative experiences reported regarding digital stories center around technical problems encountered during the implementation process (sound, music, and setup). Some students also described the implementation of digital stories in a speaking class as an obstacle to improvisational speaking. Therefore, they suggested implementing them in other courses (Ismayilli, 2025). Various suggestions are offered regarding the implementation process and the use of digital stories in different courses, such as writing and reading.

Findings regarding the observed situations during the preparation and presentation processes of students' digital stories in a foreign language speaking class. The findings obtained from the seven-week observation period within the scope of the study are presented under this heading.

Table 2

Theme	Observed Situation	Frequency of observation Little/medium/a lot		
Personal Contributions	Decreased in anxiety		+	
	Pre-class preparation			+
Contribution to the learning environment	fun process			+
	increase in technology use			+
	interest increase			+
Problem case	Program installation	+		
	voice problems		+	

Situations Observed During the Digital Story Implementation Process

When Table 2 is examined, students' increased interest, increased use of technology, and an enjoyable lesson experience are frequently observed.

Before the implementation, it was observed that students were excited during the mini-drama activities, some forgot what they were going to say, and pre-class breaks were used for preparation. In the digital stories, students presented videos they created after a specific preparation process, making them more confident. It was observed that students who were shy in class found opportunities to express themselves through the applications they prepared, and their anxiety decreased. It was noted that students enjoyed the research process, the audio recordings, and the presentations. The students' choice of interesting topics (such as a wedding ceremony, interesting festivals, the university registration journey, the introduction of a famous person) and the presentations supported by images and music made the lesson more enjoyable.

Installation and audio problems observed during the implementation were evaluated within the framework of the problem situations theme. Following the program installation and introduction lesson given at the beginning of the process, students were asked to perform sample applications. Learning to use a new program, conducting online research, and recording audio and combining it with content require students to use more technology than with the current system. Hardware deficiencies, particularly audio problems, operating system problems, installation problems, and problems with synchronizing recordings and visuals were encountered throughout the process, although these were rare. Students who had little use of technology in the current system asked the researcher questions about the program's installation and use during the first two weeks of their encounter with a new program. During the implementation period, some students stated that the program was very practical and that they would continue to use it after the implementation.

Discussion

The findings revealed that digital storytelling contributed significantly to students' personal development, particularly in reducing speaking anxiety and excitement, increasing motivation, self-confidence, and facilitating the use of technology. Students also reported that the multimodal nature of digital storytelling (integration of visuals, music, and narration) created a more supportive and engaging speaking environment.

The reduction in speaking anxiety can be explained through Cognitive Load Theory (Sweller, 2011), which suggests that multimodal input reduces learners' cognitive burden. In digital storytelling, students are not required to produce spontaneous speech under pressure; instead, they prepare and rehearse their output, which decreases anxiety and increases fluency. This finding is consistent with Aydın (2006) and Kartikasari et al. (2025), who highlight speaking anxiety as a major barrier in foreign language learning.

In addition, increased motivation and self-confidence can be interpreted through Constructivist Learning Theory, which emphasizes that learners become more motivated when they actively construct meaning and produce authentic content. Digital storytelling places students in an active role as creators rather than passive recipients of knowledge, which enhances ownership and engagement. This aligns with Lee (2014) and Castañeda (2013), who found that digital storytelling increases learner motivation and participation in foreign language classrooms.

The second major theme indicates that digital storytelling created a more interactive, enjoyable, and well-prepared learning environment. Students emphasized that they came to class more prepared, engaged in meaningful research, and experienced a more enjoyable classroom atmosphere compared to traditional speaking activities.

This improvement in classroom engagement can be explained through Sociocultural Theory (Vygotsky, 1978), which emphasizes the role of mediated learning and social interaction. Digital storytelling provides scaffolding through technology, peer collaboration, and teacher guidance, allowing students to operate within their Zone of Proximal Development (ZPD). As a result, learners are able to perform beyond their independent speaking ability.

Furthermore, the multimodal structure of digital storytelling supports multimedia learning principles (Mayer, 2001), which state that combining visual and auditory input enhances comprehension and retention. This explains why students perceived lessons as more enjoyable and effective.

The findings are consistent with Jones (2009) and Lee (2014), who reported that digital storytelling improves communication skills, organization of ideas, and learner engagement by providing structured yet creative speaking opportunities.

Despite its positive effects, students reported several challenges, including technical issues (audio recording, music integration, software installation) and concerns about reduced improvisational speaking opportunities.

These technical difficulties reflect the importance of digital literacy competence in technology-enhanced learning environments. According to Mazlan et al. (2025), insufficient technological skills may hinder the effectiveness of digital storytelling implementation, particularly in contexts where students have limited prior experience with multimedia tools.

The concern regarding lack of improvisation is theoretically linked to the distinction between planned versus spontaneous speech production. While digital storytelling supports accuracy and fluency through preparation, it may reduce opportunities for real-time communicative spontaneity. This

concern is also noted in speaking pedagogy literature, where spontaneous interaction is considered essential for communicative competence development.

Conclusion

This study investigated the use of digital storytelling as an innovative pedagogical tool for developing foreign language speaking skills. Speaking is widely recognized as one of the most challenging skills in language learning due to its cognitive and affective demands.

The findings of the study reveal that digital storytelling has a positive impact on students' speaking development. In particular, it contributes to reducing speaking anxiety and excitement, increasing motivation and self-confidence, and improving students' engagement in classroom activities. The multimodal nature of digital storytelling, combining visuals, audio, and narration, helps create a more supportive and interactive learning environment.

In addition, the study indicates that digital storytelling promotes learner autonomy and active participation. Students become more responsible for their own learning process through activities such as topic selection, script writing, and multimedia production. This process also supports the development of digital literacy skills, creativity, and collaboration among learners.

However, the findings also highlight some limitations. Technical problems such as difficulties in audio recording, software use, and synchronization issues were observed. Furthermore, some students noted that digital storytelling may limit opportunities for spontaneous speaking, as it is based on pre-prepared scripts. Therefore, it should be used as a complementary method alongside traditional speaking activities to ensure a balanced development of communicative competence.

In conclusion, digital storytelling can be considered an effective and engaging instructional approach in foreign language speaking classes. It provides both linguistic and affective benefits by enhancing students' confidence, motivation, and participation. Future research is recommended to examine its effectiveness in other language skills such as reading, writing, and listening, as well as in different proficiency levels and educational contexts.

Implications and Limitations

Implications

The study's findings have several important implications for foreign language teaching. First, digital storytelling can be effectively integrated into speaking classes to create a more engaging and anxiety-reducing learning environment. By allowing students to plan, record, and revise their speech before presentation, this approach supports the gradual development of speaking confidence, particularly among shy learners.

Second, the multimodal nature of digital storytelling, which combines narration, visuals, and audio, enhances students' comprehension and communicative expression. This suggests that teachers should incorporate multimedia-supported tasks to increase learner engagement and improve oral performance.

Furthermore, digital storytelling promotes creativity, learner autonomy, and classroom participation while also strengthening students' digital literacy skills. Therefore, it is recommended that foreign language instructors use digital storytelling as a supplementary instructional strategy alongside traditional speaking activities.

Finally, the integration of digital storytelling can extend beyond speaking instruction and be adapted to develop other language skills such as writing, reading, and listening, thereby contributing to a more holistic language learning process.

This study has several limitations. First, the sample was limited to 9 students from a single university, which restricts the generalizability of the findings. Second, the study was conducted over a period of seven weeks, which does not allow for conclusions about the long-term effects of digital storytelling on language learning. Finally, some technical difficulties were encountered during the implementation process, particularly related to audio recording, music integration, and software installation, which may have influenced students' overall experience.

Ethical Issues: Ethical permission for this study was attained from Nakhchivan State University's Ethical Committee on 23/10/2025 with decision number 2025-06.

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The Ukraine and Eastern Europe Model in Local Economic Improvement and Cultivation Strategy

Olha Dzhyhora[1*], Sergii Golubytskyi[2], Serhii Kalnyi[3], Vitalii Kostiuk[4], Yuliia Klius[5]

Abstract. *The article examines regional economic recovery through a comparative analysis of Ukraine and Eastern European countries, identifying key determinants of national economic resilience and growth. Particular attention is paid to the synergies among infrastructure, digitalization, environmental sustainability, social development, and innovation as complementary drivers of recovery. The study emphasizes the importance of integrated approaches that combine multiple sectors to ensure long-term stability and competitiveness. The methodological framework is based on systemic, structural, and comparative analytical approaches, complemented by an integral assessment method. This method aggregates indicators into eight thematic blocks, which are further synthesized into a composite index (R) measuring regional recovery. This approach enables cross-country comparison and provides a comprehensive evaluation of national recovery strategies. The findings reveal distinct recovery profiles among the analyzed countries. Ukraine achieved the highest R score (0.47), reflecting a balanced combination of infrastructure, energy, digitalization, and social reintegration. Hungary (0.45) demonstrates strong digital and innovation performance, while Slovakia and Romania (0.34) emphasize environmental and transport development. Poland and Bulgaria (0.28) show more fragmented innovation patterns. The study concludes that the most effective recovery strategies are based on "mixed" portfolios with strong inter-sectoral complementarity. For Ukraine, an optimal financing structure is proposed, prioritizing infrastructure and energy, followed by digitalization, innovation, social development, and green modernization. The research contributes a unified index for comparative analysis and offers a practical monitoring framework to support strategic planning and alignment with European development trajectories.*

Keywords: *regional economic recovery, development strategies, integral index, digitalization, environmental sustainability, innovation potential*

[1]Zhytomyr Polytechnic State University, Doctor of Economics, Zhytomyr, Ukraine
[2]Interregional Academy of Personnel Management, PhD in Law, Kyiv, Ukraine
[3]Taras Shevchenko National University of Kyiv, PhD in Economics, Kyiv, Ukraine
[4]Zhytomyr Ivan Franko State University, Candidate of Biological Science, Zhytomyr, Ukraine
[5]Volodymyr Dahl East Ukrainian National University, Doctor of Economic Sciences, Kyiv, Ukraine
[*]Corresponding author. E-mail: o.dzhyhora@ujis.in.ua
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Yerli iqtisadi təkmilləşdirmə və becərmə strategiyasında Ukrayna və Şərqi Avropa modeli

Olha Dzhyhora[1*], Sergii Qolubytskyi[2], Sergey Kalnıy[3], Vitali Kostiuk[4], Yuliya Klius[5]

Xülasə. *Məqalə Ukrayna və Şərqi Avropa ölkələrinin müqayisəli təhlili əsasında regional iqtisadi bərpa məsələsini araşdırır, milli iqtisadi dayanıqlığın və inkişafın əsas determinantlarını müəyyən edir. Xüsusi diqqət infrastruktur, rəqəmsallaşma, ekoloji dayanıqlılıq, sosial inkişaf və innovasiya kimi amillər arasında sinerjiyə, onların bərpanın tamamlayıcı drayverləri kimi roluna yönəldilir. Tədqiqat uzunmüddətli sabitlik və rəqabətqabiliyyətliliyi təmin etmək üçün çoxsektorlu inteqrasiya olunmuş yanaşmaların əhəmiyyətini vurğulayır. Metodoloji çərçivə sistemli, struktur və müqayisəli analitik yanaşmalara, eləcə də inteqral qiymətləndirmə metoduna əsaslanır. Bu metod göstəriciləri səkkiz tematik blok üzrə birləşdirərək regional bərpanı ölçən kompozit indeksə (R) çevrir. Bu yanaşma ölkələrarası müqayisəyə imkan yaradır və milli bərpa strategiyalarının kompleks qiymətləndirilməsini təmin edir. Nəticələr təhlil olunan ölkələr arasında fərqli bərpa profillərini göstərir. Ukrayna ən yüksək R göstəricisinə (0,47) malik olmuşdur ki, bu da infrastruktur, enerji, rəqəmsallaşma və sosial reinteqrasiyanın balanslı birləşməsini əks etdirir. Macarıstan (0,45) güclü rəqəmsal və innovasiya komponenti ilə seçilir, Slovakiya və Rumıniya (0,34) ekoloji və nəqliyyat istiqamətinə üstünlük verir, Polşa və Bolqarıstan (0,28) isə innovasiya komponentlərinin parçalanmış strukturu ilə xarakterizə olunur. Tədqiqat göstərir ki, ən effektiv bərpa strategiyaları sektorlararası yüksək tamamlayıcılığa malik "qarışıq" portfellərə əsaslanır. Ukrayna üçün optimal maliyyələşdirmə strukturu təklif olunur: prioritet olaraq infrastruktur və enerji, daha sonra rəqəmsallaşma, innovasiya, sosial inkişaf və yaşıl modernizasiya. Tədqiqat ölkələrarası müqayisə üçün vahid indeks təqdim edir və strateji planlaşdırmanı, həmçinin Avropa inkişaf istiqamətləri ilə uyğunlaşmanı dəstəkləyən praktiki monitorinq çərçivəsi formalaşdırır.*

Açar sözlər: *regional iqtisadi bərpa, inkişaf strategiyaları, inteqral indeks, rəqəmsallaşma, ekoloji dayanıqlılıq, innovasiya potensialı*

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[1]Jitomir Politexnik Dövlət Universiteti, iqtisad elmləri doktoru, Jitomir, Ukrayna
[2]Regionlararası Personal İdarəetmə Akademiyası, hüquq üzrə fəlsəfə doktoru, Kiyev, Ukrayna
[3]Taras Şevçenko adına Kiyev Milli Universiteti, iqtisad üzrə fəlsəfə doktoru, Kiyev, Ukrayna
[4]Jitomir İvan Franko Dövlət Universiteti, biologiya elmləri üzrə fəlsəfə doktoru, Jitomir, Ukrayna
[5]Volodymyr Dahl Şərqi Ukrayna Milli Universiteti, iqtisad elmləri doktoru, Kiyev, Ukrayna
[*]Məsul müəllif. E-poçt: o.dzhyhora@ujis.in.ua
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Introduction

The relevance of the study is determined by the deep structural, economic and social challenges faced by Ukraine as a result of military aggression and the objective need to restore the regional economy on a qualitatively updated basis. The large-scale destruction of infrastructure, disruption of logistics links, and degradation of production potential have actualized the need for a conceptual rethinking of regional development mechanisms in the context of Ukraine's integration processes into the European economic area. The issues of rational use of the resource potential of regions, their digital transformation, and the development of strategies focused on innovation, sustainability, and competitiveness gained a special status (Tymoshenko, 2024).

The scientific problem lies in the lack of a comprehensive methodological framework that would integrate the task of restoring the economic potential of regions with the long-term strategic goals of sustainable development. The issues of adapting European practices to the specifics of the Ukrainian context, in particular in terms of regional resource management, digitalization of the public sector, modernization of production infrastructure, and creation of favorable conditions for human capital development, remain insufficiently developed (Kulinich & Obushok, 2024). Identification of optimal models of regional economic recovery requires a thorough scientific justification, harmonization of national and local priorities, as well as the design of a management system capable of ensuring sustainability, efficiency, and full integration of Ukraine into the European economic space.

In the scientific space, where the issues of regional development are discussed, several research approaches have been formed to interpret the essence of this phenomenon, its goals and factors. Scientists, in particular Al Zoubi (2024), Firlej et al. (2024), define development as a set of qualitative and quantitative changes that occur under the influence of internal and external factors and ensure a transition to a more balanced state of the regional economic system. This shortcoming is critical in the current recovery environment, as the effectiveness of regional policy is determined by the system's ability to adapt to crisis challenges and the corresponding transformations of the country's economic structure.

Authors such as Ji et al. (2025) and Martyniuk et al. (2020) have studied the processes of spatial differentiation, structural changes, and transformational trends within regional economic systems. Their work proves that regional development is a dynamic process that covers the economic, social, environmental, and institutional spheres, and its result is an increase in the competitiveness of territories and living standards. At the same time, the interaction between structural, institutional, and spatial factors of regional development in the context of digitalization and military reconstruction remains insufficiently studied within existing models.

Studies by Biru et al. (2024), Jaźwiński (2023), Novykova et al. (2023) and Trejo Nieto (2025) have shown that the key criterion for development is the region's ability to sustainably reproduce its resources, as well as ensure social and environmental balance. At the same time, there is a problem of reconciling economic and environmental priorities, as most concepts leave the environmental component out of the systemic assessment of economic dynamics. This approach narrows the understanding of development as a complex process, where economic growth should be combined with environmental protection and increased social cohesion.

In the works of McCaffrey & Poitiers (2024). Medeu et al. (2025), Zakari & Musibau (2023), economic development is seen as the result of the targeted impact of public policy, which should coordinate the activities of government, business, and the public sector. In turn, Tyrkalo et al. (2022), Sumets et al. (2022) and Javaid et al. (2024) emphasize that the effectiveness of strategic management is determined by the degree of integration between levels of government and the ability of regions to implement their own development strategies. However, the question of institutional mechanisms for implementing such strategies remains open, especially in the context of decentralization, when regional entities receive more autonomy but do not always have sufficient financial and human resources to use it effectively.

A significant contribution was made by Bokovets et al. (2024), Hamann (2019), who emphasize that regional development is not only an economic but also a socio-cultural process that shapes new patterns of population behavior, increases the role of human capital and innovative competencies. At the same time, the issue of assessing intangible factors of development, such as innovation, social activity, and trust in institutions, which do not have universal dimensions but have a significant impact on competitiveness, remains problematic.

Some authors, such as Almazán-Gómez et al. (2025), Hramotniev et al. (2025), Suhendra et al. (2025), propose a comprehensive approach that takes into account human potential, the level of institutional development, innovation capabilities, and entrepreneurial activity. Their work demonstrates that regional development depends on the ability of society to create conditions for the effective use of intangible assets and knowledge. However, most studies lack a systematic analysis of the impact of digitalization on regional processes, as well as the relationship between digital innovations, economic system sustainability, and regional security. Thus, the review of the scientific literature shows that despite the significant amount of available research, the issue of regional economic recovery requires further conceptualization in the context of Ukraine's integration into the European "family".

The aim of the study is to substantiate the ways of regional economic recovery and the use of sustainable development strategies on the example of Ukraine and Eastern European countries.

Methods

The methodological basis of the study is based on systemic, structural-analytical and comparative approaches that provide a comprehensive study of the dynamics of socio-economic processes within national and supranational recovery programs. The paper applies an integral method of evaluating the effectiveness of programs, which makes it possible to aggregate heterogeneous quantitative indicators into a single generalized evaluation index. The integral index will be calculated by the formula:

$$R = \frac{\sum_{i=1}^{n} W_i}{n} \quad (1)$$

where R is the integral index of the effectiveness of recovery programs;

Wi is the average normalized value of indicators for each of the assessment blocks;

n is the number of blocks included.

For each block, the indicators are calculated as the arithmetic mean of normalized partial data:

$$W_i = \frac{\sum_{j=1}^{m} Y_{ij}}{m} \quad (2)$$

where $Y_{(ij)}$) is the normalized value of *the j-th* indicator in the *i-th* block;

m – number of indicators within the block.

Normalization is carried out by the method of min↔ max:

$$Y_{ij} = \frac{X_{ij} - X_{min}}{X_{max} - X_{min}} \quad (3)$$

where $X_{(i)\ is}$the actual value of the indicator;

X_{max}, X_{min}– maximum and minimum values among all programs.

The study uses the primary statistical base (Annex A), which includes statistics on national regional development programs of both Ukraine and the group of Eastern European countries. All indicators are brought to a single unit of measurement (million euros) and normalized against the largest program to ensure comparability.

Results

The Architectonics of Creating the Potential for Regional Economic Recovery: The Military Aspect of Ukraine

In order to ensure the ongoing stabilization of regional economic recovery, the processes of coherence of strategic goals and policies of national economic development should be of primary importance. Also, intensifying compliance with the management functions of processes that ensure operational coherence between levels of government, institutional stakeholders and territorial communities forms a controlled trajectory of transformations based on the integration of infrastructure reconstruction, modernization of the production base, energy transition and social cohesion into a single model of structural renewal (Ukraine on the way to the EU: Realities and perspectives, 2022) (Figure 1).

Areas of reproduction and cooperation
Sustainable development direction
Digital transformation direction
Area of regional cooperation
Aimed at:
- strengthening the economic, social and environmental stability of the regions;
- systematic improvement of performance while respecting the limits of environmental safety and social responsibility;
- environmental protection and rational use of resources to preserve them for future generations;
- ensuring sustainable standards of quality of life for all segments of the population;
- formation of social values, ideological guidelines and cultural consciousness based on the principles of balanced development.
Aimed at:
- Achieving a positive effect through the widespread introduction of digital technologies;
Increasing the efficiency of management decisions and optimizing resource flows;
creating a new digital culture and models of interaction between development actors;
- ensuring equal access to knowledge, innovations and digital services for all segments of the population;
- development of a safe and comfortable living environment through intelligent management systems, electronic services, and smart cities;
- improving living conditions and creating a comfortable space for citizens through the integration of digital solutions into the social, educational, and transportation sectors.
Aimed at:
- identifying and developing the unique spatial and cultural characteristics of each region;
- taking into account the geographical location, logistical advantages and potential for cross-border cooperation;
strengthening territorial governance, effective administrative interaction and institutional capacity;
- improving the legal and regulatory framework for regional development;
- formulation of policies based on cultural and value orientations and social cohesion.
Additionally, it provides for:
- overcoming poverty, increasing entrepreneurial activity and creating new jobs;
- Involvement of all population groups in the processes of recovery and modernization, including rural areas;
- protecting the environment, counteracting environmental disasters and technological risks;
- improving the livelihoods of the population and its cultural development;
- optimizing the use of natural and financial resources to improve the effectiveness of regional policy.
Additional manifestations:
- intensification of international activities of the regions of Ukraine and Eastern Europe;
- increasing their competitiveness within the single European space;
- combining local potentials and resources with foreign investments, developing cross-border initiatives;
- creating a synergistic effect from the integration of local economic systems;
- strengthening interdependence between regional communities aimed at sustainable growth, innovation and spatial cohesion in the regions of Central and Eastern Europe.

Figure 1

Conceptual framework for the development of regional recovery and cooperation between Ukraine and Eastern Europe

Source: Created by the authors.

Involvement of the regions of Ukraine and Eastern Europe in cross-border initiatives, from digital services and shared data centers to smart specialization programs to stimulate deeper mobilization processes and efficient use of the existing potential of the territories, creates a synergistic effect in the form of new market niches, increased productivity, and increased resilience to economic shocks (Beisengaliyev & Kossymbayeva, 2025).

Using a systemic approach, the authors should identify a triad of basic processes for which management functions should be clearly defined and institutionalized. First, the development of regional economic systems as integral spatial complexes on the basis of diversification of growth sources and increased resilience to external threats. Secondly, the transformation of the potential-forming space, i.e., the mobilization and reconfiguration of the region's key resources: human capital, infrastructure, natural resource base and knowledge networks towards their greater productivity and environmental balance (Gorokhova et al., 2024). Thirdly, digitalization as a cross-cutting mechanism for manageability, transparency, and accelerated scaling of decisions in policy planning, monitoring, and evaluation (Table 1).

Table 1

Management functions for regional economic recovery and development strategies for Ukraine and the countries of Eastern Europe

Management functions	**Strategies for the recovery of regional economic systems**	**Ensuring the transformation of economic potential**	**Digitalization in the context of regional recovery**
1	2	3	4
Social	Improving human subjectivity, quality of life and poverty reduction in the regions of Ukraine and Eastern Europe in accordance with the principles of sustainable development	Overcoming disproportions in the lives of the population of different territories, in particular between urban and rural populations, with a focus on intellectualization and capitalization of human potential for post-crisis recovery	Ensuring access to quality digital services, creating infrastructure for social protection, and improving the efficiency of services through digital platforms
Reproductive	Development of plans and programs for balanced territorial recovery, taking into account available resources in post-conflict regions	Planning to maximize the potential of the territories to achieve strategic recovery goals, transformation and resource mobilization in the context of regional strategies	Planning for the introduction of digital tools for expanded reproduction, building digital infrastructure and cybersecurity systems for sustainable development

Organizational	Ensuring the interaction of all actors of regional systems, employment and efficient use of resources in the process of economic recovery	Taking into account regional peculiarities in capacity building and transformation with a focus on the needs of end users in Eastern Europe	Focusing on the formation of new areas of economic activity, rationalization of resource use through digital coordination and process optimization
Innovation.	Directing regional development in the innovation and information direction for the formation of a post-industrial society in the context of the recovery of Ukraine and neighboring countries	Formation and use of innovative potential to increase the competitiveness of regions in long-term growth strategies	Development of innovative and digital infrastructure with regard to regional peculiarities, implementation of technologies for accelerated economic recovery
Distributional	Effective redistribution of resources to achieve self-sufficiency and self-financing of regional recovery	Stimulating the rational use of the region's own resources and potential, mobilizing potential opportunities for strategic development	Stimulation and concentration of efforts on highly efficient digital technologies and new areas of production to strengthen regional resilience

Source: Compiled on the basis of: (United Nations, 2024; UNDP, 2022; UN DESA, 2024).

These functionalities are dual in nature: on the one hand, they are independent tools for influencing regional processes. Each of them forms its own sphere of action aimed at improving the efficiency of resource management, and on the other hand, they remain interdependent, as their implementation is subject to the overall goal of modernizing the spatial economy, ensuring cohesion and increasing the resilience of regions within the European Economic Area (Ordonez-Ponce et al., 2021).

Between February 2023 and February 24, 2024, the World Bank, together with the Government of Ukraine and the European Commission, prepared a large-scale analytical report "Rapid Assessment of Damage and Recovery Needs", which became the first systematic document to quantify the extent of the destruction caused by full-scale aggression and identify priority areas for reconstruction, taking into account the socio-economic specifics of individual regions. According to the study, Ukraine's priority reconstruction needs amounted to USD 22 billion, including the restoration of energy and water supply. This includes the reconstruction of the energy sector, housing, social, transport and critical infrastructure, as well as measures to ensure life support in the areas that have suffered the greatest destruction (Figure 2) (World Bank, 2025).

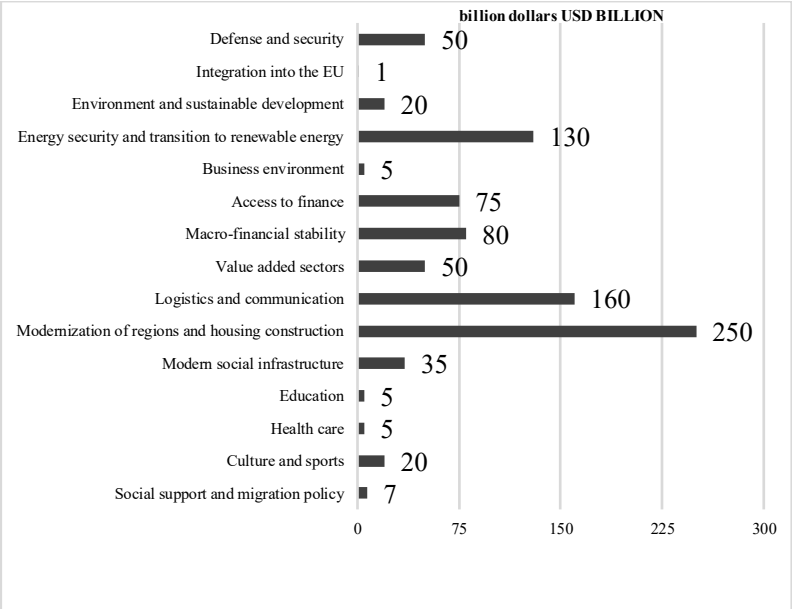

Figure 2
Structure of financing needs for regional economic recovery of Ukraine until 2032, billion USD. USD

Source: Based on the World Economic Forum (2024).

That is why the current analytics is dynamic and is constantly updated as new data is obtained. In the context of the Eastern European region, the results of the assessments are becoming systematic: they show that the processes of spatial reconstruction in Ukraine are already forming the latest architectonics of regional development, similar to the post-crisis transformations in Eastern European countries (Shpak et al., 2024). These processes actualize the need to develop integrated strategies aimed at restoring territorial integrity, stimulating intraregional mobility, increasing investment attractiveness, and creating preconditions for balanced development within the European Economic Area.

European Guidelines for Supporting and Sustaining Regional Development

At the level of national strategies, Eastern European countries are gradually forming their own comprehensive approaches to regional economic recovery, focusing on the European framework priorities for development set by EU institutions within the framework of spatial, innovation and social cohesion programs. At the same time, there are significant differences in the content and structure of policies aimed at economic growth within the regions of Eastern Europe, due to different levels of economic maturity, specific macroeconomic environment, historical development models, and the degree of approximation to EU standards (U-LEAD with Europe, 2023). Countries such as the Czech Republic and Hungary are actively integrating industrial transformation, digitalization of production processes, and green infrastructure modernization into their strategies, while Bulgaria and Romania focus on regional development balance and increasing the resilience of peripheral areas (European Commission, 2023; Makedon et al., 2024). Slovakia and Poland, in turn, demonstrate a systematic approach to combining environmental policy with industrial initiatives aimed at decarbonizing production, developing transport infrastructure, and energy independence (Figure 3).

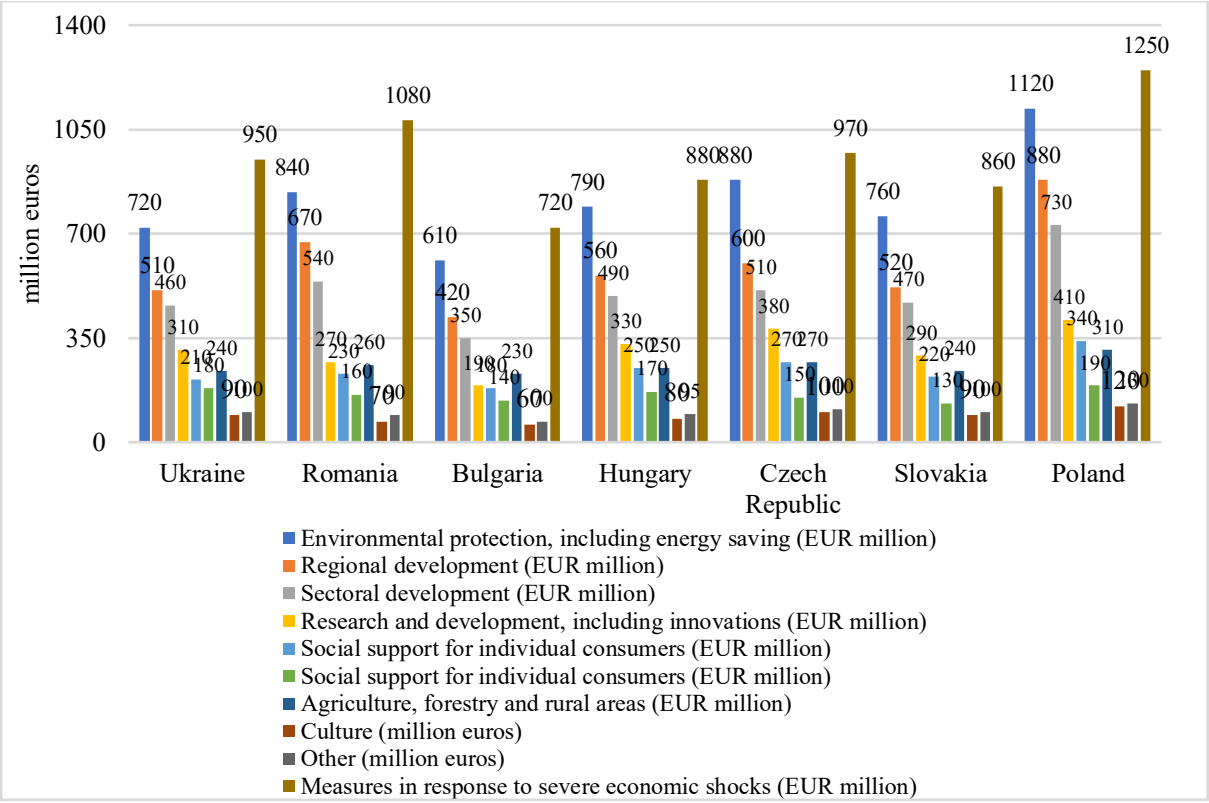

Figure 3

Structure of state aid in the main areas of economic recovery/development in Ukraine and Eastern Europe, 2023, EUR million

Source: Built on the basis of: European Commission (2024).

About half of the European Union countries have national strategic documents that define the basic directions of regional development and economic recovery after the crises of the last decade (Belu Manescu, 2024). In particular, the Czech Republic and Hungary, among other countries, have introduced special concepts of territorial cohesion that focus on innovative regional growth, digital transformation of governance, and institutional strengthening of local economies. Similar program documents are also in place in Slovakia, Poland, Romania, and Bulgaria, where reports on the progress of implementation of recovery strategies, financing of infrastructure projects, environmental modernization, and the formation of new cluster initiatives are updated annually (IRENA, 2023).

An analysis of the structure of policies and programs implemented in Eastern European countries in 2023 (Fig. 4) shows that the dominant areas of state regulation were to support the digital and environmental transformation of regions, develop skills and human capital, create an enabling environment for innovation, and remove administrative barriers and build industrial ecosystems (Figure 4).

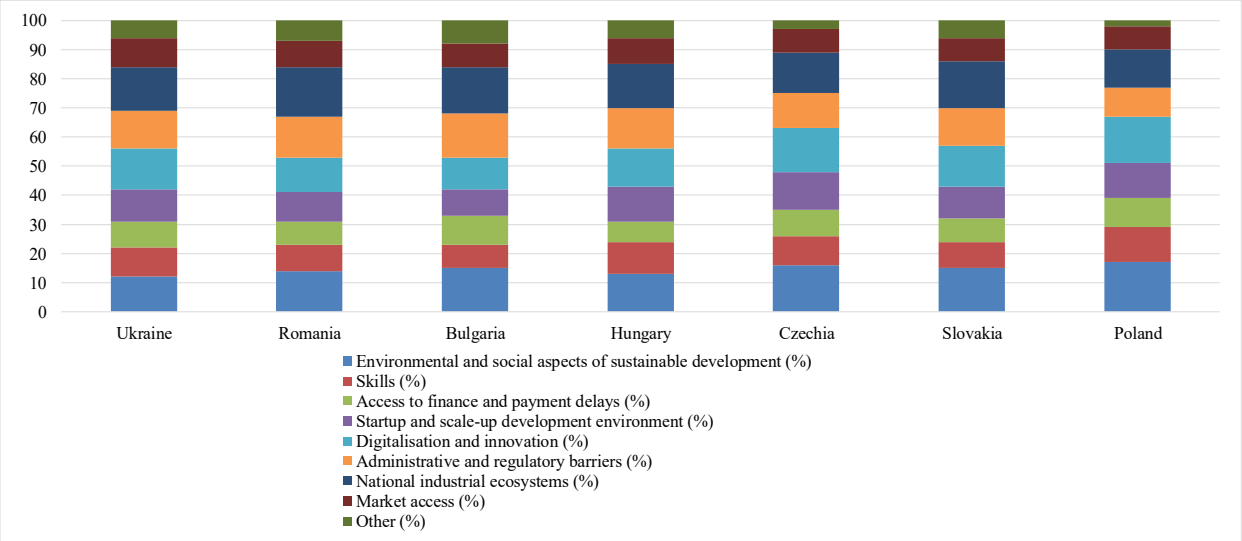

Figure 4
Structure of the main barriers and drivers of regional economic development in Ukraine and Eastern Europe

Source: Based on: Eurostat (2025).

According to an analytical report by the World Economic Forum (WEF), the global economic system in its conceptual development is only halfway to achieving a conditionally ideal growth model that involves an organic combination of innovation, inclusiveness, sustainability, and resilience, which are considered four interrelated dimensions of future economic progress. Within this approach, innovation is the weakest link, as the global average score is only 45.5 points out of 100. This situation is explained by the high concentration of innovation centers in a small number of developed economies, while most countries, including Eastern Europe, are still at the stage of transforming their innovation ecosystems and forming sustainable mechanisms of technological development. For both Ukraine and Eastern European countries, this problem is painful, because the process of economic recovery in the face of military, energy, and climate challenges requires a combination of environmental, innovative, and social approaches to regional development (Tymokhova et al., 2025; World Economic Forum, 2024).

For Ukraine, these manifestations and shortcomings have already become strategically significant, as recovery programs after the devastating effects of the war require the creation of sustainable institutional structures, diversification of economic ties, and attraction of foreign investment.

Econometric Evaluation of the Effectiveness of Regional Economic Recovery Programs in Ukraine and Eastern Europe

The authors propose a model for evaluating regional economic recovery based on an integral approach that provides an in-depth understanding of the complex architecture of spatial processes that determine the current landscape of economic dynamics in a particular country (Chen & Xing, 2025). The corresponding calculations were made using formulas (1–3). Then, for each country, the authors determined normalized indicators for all blocks (Table 3), using the statistical data from Appendix A.

Table 3
Normalized block indices of the effectiveness of regional recovery programs and the integral index *R* for Ukraine and Eastern European countries

Country	Economic (E)	Digital (D)	Environmental (G)	Social (S)	Innovative (I)	Energy (EN)	Investment (P)	Resilience (Res)	Integral index R
Ukraine	0.51	0.54	0.56	0.49	0.42	0.39	0.52	0.38	0.47
Romania	0.35	0.41	0.36	0.32	0.28	0.30	0.33	0.31	0.33
Bulgaria	0.26	0.23	0.28	0.21	0.20	0.22	0.25	0.18	0.23
Hungary	0.44	0.48	0.45	0.47	0.50	0.41	0.46	0.42	0.45
Czech Republic	0.33	0.36	0.38	0.35	0.32	0.29	0.34	0.30	0.33
Slovakia	0.36	0.30	0.37	0.33	0.27	0.35	0.38	0.34	0.34
Poland	0.32	0.25	0.30	0.28	0.25	0.26	0.29	0.29	0.28
CEE Aggregate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: Compiled by the authors.

Let's take an example of the calculation for Ukraine. Maximum values among all programs: X_1max = 100 million. EUR, X_2max = 28.4 million. EUR, X_3max = 189.4 million. EUR. Minimum: X_1min = 2.5 mln. EUR, X_2min = 0.75 million. EUR, X_3min = 5 million. EUR.
For Ukraine (X_1= 50 mln. EUR; X_2= 15 million. EUR; X_3= 100 million. EUR) we get:

$$Y_{1,UA} = \frac{50000 - 2500}{100000 - 2500} = 0.487, Y_{2,UA} = \frac{15000 - 750}{28400 - 750} = 0.519, Y_{3,UA} = \frac{100000 - 5000}{189400 - 5000} = 0.514.$$

Average value for the economic development block of Ukraine:

$$WE(UA) = \frac{0.487 + 0.519 + 0.514}{3} = 0.507 \approx 0.51.$$

The calculation for other programs and countries is done in a similar way.

According to the results of the integrated assessment (Table 3), Ukraine, with an average generalized efficiency index of *R* = 0.47, took one of the leading places among Eastern European countries, second only to the consolidated EU Cohesion Policy for CEE program *(R* = 1.00), which contains a set of European cohesion policy instruments. Ukraine's high score is explained by the scale of the

Ukraine Facility program due to the martial law, which covers not only infrastructure and energy recovery, but also digital transformation, social stabilization, and mandatory support for innovation.

While the integral indices for Hungary (R = 0.45), Slovakia (R = 0.34), and Romania (R = 0.33) reflect relatively balanced but smaller programs, the results of Bulgaria *(*R = 0.23) and Poland (R = 0.28) show a lower threshold of effectiveness, due to fragmented funding and a limited share of innovation components in the expenditure structure (Makedon et al., 2025). It should be noted that even EU countries with more developed institutional structures do not always achieve a high level of synergy between sectoral policies, while in Ukraine, despite martial law, there is a tendency to harmonize recovery policies, in particular within the framework of IFI programs (World Bank, EIB, EBRD) and the EU's direct budget support mechanism (Table 4).

Table 4
Comparative assessment of regional recovery programs: integral index R and qualitative characteristics of effectiveness

Country/Program	Integral index R	Economic coherence	Digital transformation	Innovation capacity	Environmental sustainability	Social impact
Ukraine Facility (Ukraine)	0.47	High	Moderate	Medium	High	High
TOP Plus (Hungary)	0.45	High	High	High	Average	High
OPII (Slovakia)	0.34	Medium	Low	Medium	High	Average
ROP (Romania)	0.33	Average	Moderate	Low	Medium	Low
IROP (Czech Republic)	0.33	Average	Average	Low	Average	Average
EPOP (Poland)	0.28	Low	Average	Low	Low	Medium
OPRG (Bulgaria)	0.23	Low	Low	Low	Medium	Low
EU Cohesion Policy (CEE)	1.00	Very high	High	High	High	High

Source: Compiled by the authors.

Comparison of the block components shows that the economic block was the most important for the formation of the overall development index. In particular, countries with large amounts of funding for infrastructure, transportation and energy have significantly higher integrated results. For Ukraine, this block now accounts for about 43% of the overall index, which emphasizes the strategic role of

restoring transport corridors, logistics systems, and industrial zones in the national economic recovery.

At the same time, the digital block demonstrated one of the highest correlations with the level of expected GDP growth, especially in the case of Romania and Hungary's programs. This indicates that even relatively small investments in the digitalization of public administration, e-services, and digital education provide a high multiplier effect, and contribute to transparency, reduced transaction costs, and increased efficiency of public finances. Ukraine has considerable potential in this regard, as the national digital platform Diia already integrates more than 30 administrative services and can become the core of the digital reconstruction of public administration.

The environmental block in Eastern European countries is mainly focused on the implementation of European climate directives and is associated with financing projects to restore energy efficiency, modernize water supply, waste management, and develop green infrastructure. In this context, despite the war's destruction, Ukraine has the opportunity to integrate an environmental component into reconstruction programs based on Slovak and Czech models focused on green cities and energy-efficient municipal projects.

The authors also note that the social pillar, which includes investments in employment, education, and social inclusion, remains the weakest link for most countries in the region. Ukraine is estimated to have a relatively high level of focus on the social reintegration of internally displaced persons and labor market adaptation, but needs to deepen coordination between employment, retraining, and digital skills programs.

The distribution of weighting coefficients between the blocks showed that with a 10% increase in the share of funding for the innovation and digital blocks, the integral index increases by an average of 0.03–0.05 points, while the increase in infrastructure funding has a less pronounced effect (up to 0.02 points). This is explained by the effect of "structural saturation," when excessive concentration of resources in traditional sectors (roads, energy) yields lower returns without accompanying digital and social reforms. For Ukraine, the optimal balance of sectoral distribution is 35–40% of funds allocated to infrastructure and energy, 20% to digitalization and innovation, 15% to social development and employment, 15% to environmental programs, and the rest to ensure the economic sustainability of the regions.

Discussion

The results of the quantitative assessment of the effectiveness of regional recovery programs for Ukraine and Eastern European countries are generally consistent with current publications and analytical reports that emphasize the role of institutionally coordinated investments in infrastructure, energy transition, and digital transformation as flagship drivers of post-crisis growth (Petrukha et al., 2023; European Commission, 2023; World Economic Forum, 2024; Almazán-Gómez et al., 2025). The advantage of Ukraine over most Eastern European countries in terms of the integral index *R* revealed in the proposed model does not contradict the works that document the high multiplier effect of conditional financing from EU partners and international financial organizations in the presence of a clear programmatic framework (McCaffrey & Poitiers, 2024; Hramotniev et al., 2025). At the same time, these estimates partially correct the more cautious conclusions of some studies about the "limited return" on infrastructure spending in catching-up countries: *R* growth is recorded to be faster when infrastructure investments are accompanied by digital and innovative components, which is consistent with the thesis of the complementarity of the financial capital used.

A comparative analysis with empirical studies on the green transition shows consistency: a higher share of the environmental pillar correlates with better medium-term results, but only if cities and

regions have the institutional capacity for project management (IRENA, 2023; Medeu et al., 2025). At the same time, the findings on the relative weakness of the social sector in most countries (except Ukraine) partially contradict studies that consider social spending as the main catalyst for labor market recovery. Our data show that without integration with digital employment services and educational tracks, their multiplier is lower than expected.

The scientific novelty of the study lies in the construction of a single integral index *R*, which includes eight thematic blocks and shows how to conduct a cross-country comparison of programs of different architectures. The methodological contribution is complemented by analytical commentary, through the introduction of the identification of profiles of national development (restoration) programs (infrastructure-oriented, digitally integrated, green, social and reintegration) and the demonstration that the highest *R* values are achieved in "mixed" portfolios with a high degree of inter-block complementarity. The practical significance for Ukraine lies in the clearly defined configuration of priorities for the introduction and implementation of both regional and national development programs, in the current conditions of war and military pressure on the economy.

The issues of measuring intangible factors (trust, managerial capacity, quality of procurement procedures) and time lags of returns remain unresolved; future research should expand the panel to the regional level of NUTS-2 and apply dynamic models to track the diffusion of effects in time and space.

Conclusion

The analytical reconstruction of Ukraine's regional recovery has shown that the manageability of growth trajectories is determined by the linkage between strategic and operational levels of governance, where social, reproductive, organizational, innovative, and distributional functions should be considered as interrelated mechanisms. It has been determined that cross-border initiatives with Eastern Europe, from smart specialization to common logistics corridors, enhance the multiplier effect of investments, which together form the basis for the structural modernization of the regional economy, increase its resilience to shocks and lay the foundation for an integrated return to a sustainable growth trajectory.

A comparative analysis of the national approaches of Eastern European countries to the European Cohesion Framework has shown that the most effective strategies are those in which industrial transformation, digitalization of public services, and green modernization are integrated into a single budgetary and programmatic framework with clear performance indicators. Fragmented models dominated by traditional infrastructure spending provide a short-term effect but do not build long-term sustainability. It is determined that institutional compatibility with EU policy, implementation of mandatory components of digital governance and ESG criteria in project selection, as well as strengthening the capacity of regions to plan and monitor results are critical for Ukraine.

Econometric modeling has shown that Ukraine, with an index of $R = 0.47$, occupies a leading position among the analyzed countries, second only to the EU's consolidated cohesion policy. The strength of the profile is due to the combination of significant infrastructure and energy allocations with digital transformation and targeted social support. It was found that a 10% increase in the share of financing for innovation and digitalization increases the integral indicator by 0.03 to 0.05 percentage points. Additional infrastructure expenditures without accompanying reforms are characterized by lower marginal returns, which justifies the recommendation to rebalance budgets in favor of the triad "digitalization + innovation + social integration", and confirms the need for institutional strengthening of mechanisms for monitoring and managing the implementation of development programs at the regional level.

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Appendix A

Primary statistical indicators (in millions of euros) for the regional recovery and development programs of Ukraine and Eastern Europe (2023–2027) (European Commission, 2024; UN DESA, 2024).

№	Program	Country/Region	Total budget (EUR million)	Allocation to infrastructure (transport, housing; EUR million)	Digitalization focus (e-governance, IT; EUR million)	Allocation to environmental sustainability (green infrastructure; EUR million)	Allocation to social development (employment, education; EUR million)	Allocation to innovation (R&D, technology; EUR million)	Allocation to energy (renewable sources; EUR million)	Attracted private investment (leverage; EUR million)	Expected impact on GDP (growth; EUR million)	Allocation to regional resilience (resilience; EUR million)
1	Ukraine Facility (Recovery and Resilience Plan)	Ukraine	50 000	20 000	7 500	10 000	7 500	2 500	1 500	15 000	100 000	1 000
2	Regional Operational Program (ROP)	Romania	6 700	2 500	1 871	1 200	800	400	500	2 000	13 400	429
3	Operational Program Regions in Growth (OPRG)	Bulgaria	2 500	1 000	500	600	200	100	300	750	5 000	50
4	Territorial and Settlement Development Operational Program (TOP Plus)	Hungary	22 000	8 000	2 000	3 000	5 300	1 500	1 000	6 600	44 000	1 200
5	Integrated Regional Operational Program (IROP)	Czech Republic	5 000	2 000	800	800	1 000	500	400	1 500	10 000	0
6	Operational Program Integrated Infrastructure (OPII)	Slovakia	6 000	3 000	600	1 200	800	200	1 000	1 800	12 000	400

7	Eastern Poland Operational Program (EPOP)	Poland	2 500	1 000	300	500	400	200	100	750	5 000	250
8	EU Cohesion Policy for Central and Eastern Europe (aggregate)	Eastern Europe (CEE)	100 000	37 500	13 571	17 300	16 000	5 400	4 800	28 400	189 400	3 329

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Green Innovation and Sustainable Development: Conceptual Model and Analytical Approach

Leyla Aliyeva[1], Ulkər Hasanzade[1], Asif Abdullayev[1], Mehseti Esgerova[1*], Kemale Tahmezbeyova[1]

Abstract. *In the modern era, climate change, resource scarcity, and escalating environmental challenges have questioned the effectiveness of traditional economic development models and highlighted the need for their reconsideration. Global warming, biodiversity loss, and energy security challenges, in particular, demand that economic systems be structured based on more sustainable and environmentally oriented principles. In this context, the concept of the green economy and one of its key components, green innovation, stands at the center of contemporary development strategies. Green innovation is not limited to technological advancements; it also encompasses the improvement of management mechanisms, efficient use of resources, waste reduction, and the implementation of environmentally friendly production processes. Green innovation serves as a key driving force in ensuring sustainable development by creating a balance between economic growth and environmental protection. The primary objective of this study is to systematically analyze the existing interrelationship between green innovation and sustainable development within a conceptual model framework and, using an analytical approach, to comprehensively evaluate its economic, social, and environmental impacts. The research employs systematic methods, comparative analysis, and theoretical generalization. These methods allow for an examination of the mechanisms of green innovation's effects at various levels (micro, meso, and macro). The analyses indicate that green innovation promotes more efficient resource use, reduces production costs, increases energy efficiency, and minimizes negative environmental impacts. At the same time, these innovations contribute significantly to reducing carbon emissions, expanding the use of alternative and renewable energy sources, and maintaining ecological balance. From a social perspective, green innovation facilitates the creation of new jobs, enhances quality of life, and fosters environmental awareness. In conclusion, green innovation plays a crucial role in ensuring long-term and inclusive economic growth. This approach ensures that economic development is sustainable not only in quantitative terms but also in qualitative aspects, supporting a balanced development model that takes into account the interests of future generations.*

Keywords: *green energy policy, renewable energy investment, innovation economics, sustainable development, panel data analysis, GDP growth, environmental sustainability*

[1]Nakhchivan State University, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: esgerovamenseti@ndu.edu.az
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Yaşıl innovasiya və dayanıqlı inkişaf: konseptual model və analitik yanaşma

Leyla Əliyeva[1], Ülkər Həsənzadə[1], Asif Abdullayev[1], Məhsəti Əsgərova[1*], Kəmalə Təhməzbəyova[1]

Xülasə. *Müasir dövrdə iqlim dəyişikliyi, resurs qıtlığı və artan ekoloji problemlər ənənəvi iqtisadi inkişaf modellərinin effektivliyini sual altına almış və onların yenidən nəzərdən keçirilməsinə ehtiyac yaratmışdır. Xüsusilə qlobal istiləşmə, biomüxtəlifliyin azalması və enerji təhlükəsizliyi ilə bağlı çətinliklər iqtisadi sistemlərin daha dayanıqlı və ekoloji yönümlü prinsiplər əsasında qurulmasını tələb edir. Bu kontekstdə yaşıl iqtisadiyyat anlayışı və onun əsas komponentlərindən biri olan yaşıl innovasiya müasir inkişaf strategiyalarının mərkəzində dayanır. Yaşıl innovasiya yalnız texnoloji yeniliklərlə məhdudlaşmır; o, həmçinin idarəetmə mexanizmlərinin təkmilləşdirilməsini, resurslardan səmərəli istifadəni, tullantıların azaldılmasını və ekoloji cəhətdən təmiz istehsal proseslərinin tətbiqini əhatə edir. Yaşıl innovasiya iqtisadi artım ilə ətraf mühitin qorunması arasında balans yaratmaqla dayanıqlı inkişafın təmin olunmasında əsas hərəkətverici qüvvə kimi çıxış edir. Bu tədqiqatın əsas məqsədi yaşıl innovasiya ilə dayanıqlı inkişaf arasında mövcud qarşılıqlı əlaqəni konseptual model çərçivəsində sistemli şəkildə təhlil etmək və analitik yanaşma vasitəsilə onun iqtisadi, sosial və ekoloji təsirlərini hərtərəfli qiymətləndirməkdir. Tədqiqatda sistemli yanaşma, müqayisəli analiz və nəzəri ümumiləşdirmə metodlarından istifadə olunmuşdur. Bu metodlar yaşıl innovasiyanın müxtəlif səviyyələrdə (mikro, mezo və makro) təsir mexanizmlərini araşdırmağa imkan verir. Aparılan təhlillər göstərir ki, yaşıl innovasiya resurslardan daha səmərəli istifadəyə, istehsal xərclərinin azaldılmasına, enerji səmərəliliyinin artırılmasına və ətraf mühitə mənfi təsirlərin minimuma endirilməsinə kömək edir. Eyni zamanda, bu innovasiyalar karbon emissiyalarının azaldılmasına, alternativ və bərpa olunan enerji mənbələrinin istifadəsinin genişləndirilməsinə və ekoloji tarazlığın qorunmasına mühüm töhfə verir. Sosial baxımdan isə yaşıl innovasiya yeni iş yerlərinin yaradılmasını, həyat keyfiyyətinin yüksəldilməsini və ekoloji şüurun formalaşmasını təşviq edir. Nəticə etibarilə, yaşıl innovasiya uzunmüddətli və inklüziv iqtisadi artımın təmin edilməsində mühüm rol oynayır. Bu yanaşma iqtisadi inkişafın yalnız kəmiyyət deyil, həm də keyfiyyət baxımından dayanıqlı olmasını təmin edərək, gələcək nəsillərin maraqlarını nəzərə alan balanslaşdırılmış inkişaf modelini dəstəkləyir.*

Açar sözlər: *yaşıl enerji siyasəti, bərpa olunan enerji investisiyaları, innovasiya iqtisadiyyatı, dayanıqlı inkişaf, panel məlumat analizi, ÜDM artımı, ekoloji dayanıqlılıq*

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[1]Naxçıvan Dövlət Universiteti, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: esgerovamenseti@ndu.edu.az
Daxil oldu: 4 Fevral 2026; Qəbul edildi: 7 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

The acceleration of globalization and industrialization processes in recent decades has driven the rapid development of the global economy while simultaneously increasing pressure on the natural environment. Expanding industrial production, growing energy demand, rapid urbanization, and the inefficient use of natural resources have intensified global environmental problems such as climate change, air and water pollution, soil degradation, and biodiversity loss. These developments demonstrate that traditional economic growth models are environmentally and economically unsustainable in the long term.

Conventional development approaches have primarily focused on the intensive exploitation of natural resources and the short-term maximization of economic benefits. As a result, ecological imbalances, depletion of natural reserves, and increasing risks for future generations have emerged. In response to these challenges, the concept of sustainable development has gained global recognition as a new paradigm of economic growth. Sustainable development seeks to establish a balance between economic progress, social welfare, and environmental protection (Albort-Morant et al., 2018).

In this context, innovation plays a particularly important role in ensuring sustainable development. Green innovation has become one of the major mechanisms supporting the transformation of modern economic systems. Green innovation refers to the development and application of environmentally friendly technologies, products, and management approaches that reduce negative environmental impacts and improve resource efficiency. These innovations include increasing energy efficiency, expanding renewable energy use, reducing waste generation, and promoting recycling processes (Aghion et al., 2016).

At the same time, green innovation extends beyond technological improvements aimed solely at environmental protection. It also encompasses institutional reforms, organizational transformation, sustainable business models, and changes in consumer behavior. Therefore, green innovation contributes to structural transformation across different sectors of the economy and facilitates the emergence of more sustainable production and consumption systems (Lin & Zhu, 2019).

The implementation of green innovation generates significant environmental, economic, and social benefits. Economically, it improves productivity, reduces production costs, strengthens competitiveness, and creates new market opportunities. Socially, it contributes to employment creation, improves quality of life, and increases environmental awareness. Furthermore, green innovation supports countries in fulfilling international environmental obligations and integrating into global climate policies (Khan & Khan, 2021).

In recent years, the growing importance of green innovation has attracted increasing attention from researchers and policymakers. Numerous studies have examined the relationship between green innovation, economic growth, renewable energy, and sustainable development. However, the existing literature mainly focuses on isolated dimensions of green innovation, such as environmental technologies or renewable energy consumption, while insufficient attention has been paid to the integrated role of institutional support, human capital, energy efficiency, and innovation infrastructure in promoting sustainable economic development (Ahmad et al., 2023).

Moreover, limited empirical research has investigated the multidimensional effects of green innovation within regional and developing economy contexts. In particular, the role of innovation infrastructure and institutional mechanisms in supporting sustainable regional development remains underexplored. Therefore, this study aims to analyze the relationship between green innovation and sustainable development by considering technological, institutional, and economic factors within a comprehensive analytical framework. The study also contributes to the literature by emphasizing the importance of regional innovation systems and sustainable growth strategies.

Green innovation as a strategic driver of sustainable development

Green innovation refers to the development and implementation of environmentally friendly technologies, products, and management practices aimed at reducing ecological damage while supporting economic growth and social welfare. In recent years, green innovation has become one of the central mechanisms for achieving sustainable development goals. Unlike traditional innovation models that focus primarily on productivity and profitability, green innovation integrates environmental responsibility into the innovation process.

The theoretical foundation of green innovation is closely connected with the concept of sustainable development, which emphasizes the balanced interaction between economic, environmental, and social dimensions. Green technologies contribute to reducing carbon emissions, improving energy efficiency, minimizing industrial waste, and promoting the rational use of natural resources. At the macroeconomic level, countries investing in green innovation tend to achieve more resilient and competitive economic systems.

Furthermore, green innovation supports the transition from a linear economic model toward a circular economy. In this context, enterprises increasingly adopt recycling systems, renewable energy technologies, eco-design principles, and sustainable production methods. These transformations not only improve environmental performance but also create new employment opportunities and stimulate technological advancement. Therefore, green innovation can be considered a strategic instrument for ensuring long-term sustainable development.

Table 1
Green innovation as a strategic driver of sustainable development

Strategic dimension	Role of Green Innovation	Impact on Sustainable Development
Environmental Protection	Development of eco-friendly technologies and processes	Reduction of pollution and carbon emissions
Economic Growth	Resource-efficient production and cost optimization	Increased competitiveness and long-term profitability
Energy Transition	Adoption of renewable energy technologies	Reduced dependence on fossil fuels
Industrial Transformation	Green manufacturing and circular economy practices	Sustainable industrial development
Policy Alignment	Support for environmental regulations and ESG standards	Stronger governance and sustainability compliance

Table 2
Link Between Green Innovation and Sustainable Development Goals (SDGs)

SDG Area	Contribution of Green Innovation	Expected Outcome
Clean Energy (SDG 7)	Renewable energy technologies	Energy security and reduced emissions
Responsible Consumption (SDG 12)	Circular economy practices	Waste reduction and efficiency
Climate Action (SDG 13)	Low-carbon technologies	Climate mitigation
Industry & Innovation (SDG 9)	Green technological development	Sustainable industrial growth
Sustainable Cities (SDG 11)	Smart and green infrastructure	Improved urban sustainability

Conceptual Model of Green Innovation and Sustainability Interaction

The conceptual relationship between green innovation and sustainable development can be explained through a multidimensional analytical framework. This framework demonstrates how environmental policies, technological capabilities, institutional quality, and human capital collectively influence sustainable economic outcomes (Askarova, 2025).

At the first stage of the model, environmental regulations and governmental policies act as external drivers encouraging firms to adopt green technologies. Public investments, green subsidies, carbon taxation, and environmental standards create favorable conditions for eco-innovation activities. Simultaneously, institutional support and financial accessibility increase the capacity of firms to invest in sustainable technologies (Khan et al.,2021).

The second component of the conceptual model focuses on innovation processes within organizations. Research and development (R&D), digital transformation, technological adaptation, and knowledge transfer mechanisms play a critical role in generating green products and services. Companies that integrate environmental objectives into their strategic management systems generally achieve higher levels of operational efficiency and market competitiveness (Esgerova, 2026).

Finally, the outcomes of green innovation directly affect sustainable development indicators. These outcomes include reduced environmental pollution, efficient resource utilization, increased energy productivity, social welfare improvement, and sustainable economic growth. The conceptual model therefore illustrates a dynamic interaction where green innovation acts as an intermediary mechanism connecting policy instruments and sustainable development performance (Gulaliyev et al.,2025).

Conceptual model

The model consists of three main blocks – input factors, process stage, and outputs – with a logical sequence connecting them.

1. Input Factors

The input factors, forming the initial stage of the model, represent the key determinants shaping the formation and development of green innovation. These include:

Innovation investments – Research and Development (R&D) expenditures and financial resources directed toward new technologies act as the main driving force of green innovation. High levels of investment stimulate the emergence of innovative and environmentally friendly technologies.
Government policy and regulation – Environmental standards, tax incentives, subsidies, and legal mechanisms play a crucial role in promoting green innovation. Effective government policies address market failures and strengthen the innovation environment.
Level of technological development – The technological capacity of a country or enterprise determines the potential for implementing innovations. A strong technological base facilitates faster and more effective application of green solutions.

2. Process Stage (Transformation Mechanism)

This stage reflects the main mechanisms through which input factors are transformed into the practical application of green innovation:

Implementation of green technologies – The use of renewable energy sources, clean production technologies, and environmentally innovative products is a key element of this stage.
Efficient resource utilization – Optimizing material, water, and energy resources reduces the ecological burden of production and enhances economic efficiency.
Energy efficiency – Reducing energy consumption and implementing more efficient energy systems leads to a decrease in the carbon footprint.
This stage represents the transformation process in which input factors are converted into actual economic and technological activities.

3. Outputs

The final stage of the model represents the key outcomes resulting from the application of green innovation:

Economic growth – Innovative technologies increase productivity, create new markets, and ensure long-term economic development.
Environmental sustainability – Negative environmental impacts decrease, carbon emissions are reduced, and natural resources are conserved.
Social welfare – New jobs are created, a healthier environment is promoted, and quality of life is improved.

Mathematical Representation of the Model (Conceptual Form)

The conceptual model can be expressed in a more analytical form as follows:

$$\begin{matrix} SD=f(GI) \\ SD = f(I,P,T) \\ SD=f(EG,ES,SW) \end{matrix} \quad (1)$$

Where:

GI – Green Innovation,
I – Innovation Investments,
P – Government Policy,
T – Technological Development,
SD – Sustainable Development,
EG – Economic Growth,
ES – Environmental Sustainability,
SW – Social Welfare.
In a more comprehensive form, the model can be generalized as:

$$SD=f\,(I,P,T \rightarrow GI \rightarrow EG,\ ES,\ SW) \quad (2)$$

General assessment

The proposed conceptual model demonstrates that green innovation is not merely a technological change but a complex mechanism encompassing economic and institutional transformation. The model clearly illustrates that well-designed policies, sufficient investment, and a developed technological base enhance the effectiveness of green innovation, ultimately producing positive outcomes across all components of sustainable development (Gulaliyev et al., 2025).

Thus, green innovation acts as an integrative and system-forming mechanism for ensuring sustainable development and represents one of the fundamental pillars of modern economic development models.

This can also be shown in the following table:

Table 3
Key Dimensions of Green Innovation and Sustainable Development

Dimension	Description	Examples
Environmental Sustainability	Reduction of environmental impact through innovation	Renewable energy, waste reduction technologies
Economic Efficiency	Optimization of resource use and cost reduction	Energy-efficient production systems
Social Responsibility	Improvement of social well-being and equity	Green jobs, community-based sustainability projects
Technological Innovation	Development of eco-friendly technologies	Smart grids, green ICT solutions

Social activities and awareness

Social activities play a crucial role in shaping environmental awareness and promoting sustainable development within society. Through initiatives such as environmental campaigns, community clean-up programs, educational workshops, and corporate social responsibility projects, individuals become more informed about ecological challenges and their personal responsibility in addressing them. Over time, these activities contribute to the development of a more environmentally conscious society, where sustainable behavior becomes part of daily life. The level of public awareness is directly influenced by education systems, media exposure, government policies, and community engagement. As awareness increases, individuals are more likely to adopt eco-friendly behaviors such as recycling, energy saving, and responsible consumption, thereby supporting long-term sustainable development goals.

Table 4
Environmental Awareness Levels in Azerbaijan (2015–2025)

Awareness Level	2015	2020	2025
High Awareness	10–15%	25–35%	55–65%
Moderate Awareness	30–40%	40–50%	25–30%
Low Awareness	35–40%	20–25%	10–15%
Unaware	15–20%	5–10%	<5%

Results

The empirical analysis was conducted to examine the relationship between green innovation and sustainable development indicators. The panel data estimation results demonstrate that green innovation has a positive and statistically significant effect on sustainable development outcomes. The estimated models indicate that innovation investments, technological development, and government support mechanisms positively influence sustainable economic performance. In particular, the coefficients related to green innovation variables show that increases in environmentally oriented technological activities contribute to higher economic growth and improved environmental sustainability indicators. The econometric findings also reveal that energy efficiency and renewable energy utilization significantly reduce environmental pressure and carbon emissions. Countries and regions with stronger innovation capacity and more effective environmental policies demonstrate comparatively higher sustainable development performance.

The panel estimation results further confirm that institutional support and innovation infrastructure play an important role in strengthening the effectiveness of green innovation. The positive coefficients associated with government policy variables indicate that environmental regulations, incentives, and innovation-supportive policies contribute significantly to sustainable development outcomes. The Hausman test results support the selection of the appropriate panel estimation model, while diagnostic tests indicate that the estimated models are statistically reliable. In addition, the Variance Inflation Factor (VIF) values confirm the absence of serious multicollinearity problems among the explanatory variables. Overall, the empirical findings demonstrate a strong and positive relationship between green innovation and sustainable development indicators across economic, environmental, and social dimensions.

Methodology

The analysis of green innovation and sustainable development requires interdisciplinary and multidimensional methodological approaches. Researchers commonly employ both qualitative and quantitative methods to evaluate the effectiveness of green innovation policies and their socio-economic impacts. One widely used analytical approach involves econometric modeling. Regression analysis, panel data methods, and structural equation modeling are frequently applied to examine the relationship between green innovation indicators and sustainable development outcomes. Variables such as renewable energy consumption, green patents, carbon emissions, research expenditures, and environmental performance indexes are often incorporated into empirical studies (Zhang et al., 2022).

Another important analytical method is comparative policy analysis. This approach examines how different countries or regions implement green innovation strategies and achieve sustainable development objectives. Comparative studies help identify best practices, institutional differences, and policy effectiveness across various economic systems. In addition, sustainability assessment frameworks such as ESG indicators, environmental performance indexes, and circular economy metrics are increasingly utilized in academic research. These tools provide measurable indicators for evaluating ecological efficiency, social responsibility, and governance quality. Modern analytical approaches also integrate digital technologies, including big data analytics and artificial intelligence, to monitor environmental impacts and optimize sustainable production systems. Overall, analytical approaches to green innovation demonstrate that sustainable development is not solely an environmental issue but a complex socio-economic transformation process requiring coordinated institutional, technological, and policy-based solutions.

Conclusion

The results of the study indicate that green innovation is one of the key determinants in the transformation of modern economic systems and the achievement of sustainable development. The implementation of green innovation is not limited to addressing environmental challenges; it also generates long-term and multifaceted positive impacts in economic and social spheres. In this regard, green innovation serves as a fundamental mechanism for the practical realization of sustainable development. The theoretical and analytical analyses conducted within the study demonstrate that green innovation enhances the quality of economic growth, making it more sustainable and inclusive. Efficient resource utilization, increased energy efficiency, and the application of new technologies contribute to reducing production costs and increasing productivity. This, in turn, strengthens the competitiveness of the economy and creates new development opportunities. At the same time, green innovation plays a crucial role in ensuring environmental sustainability. Its key outcomes include reduced carbon emissions, minimized environmental pollution, and the conservation of natural resources. These effects contribute to the preservation of ecosystems and the maintenance of a healthy environment for future generations.

From a social perspective, green innovation is characterized by increased employment, the creation of new jobs, and improvements in the quality of life. A cleaner and safer environment positively affects human health while fostering ecological awareness within society (Zhang & Ma, 2023).

The main findings can be summarized as follows:
- Green innovation supports economic growth and ensures its sustainability.
- It contributes to environmental balance and the efficient use of natural resources.
- It enhances social welfare and improves quality of life.
- It acts as a key element in the formation and implementation of sustainable development strategies.

In conclusion, the widespread implementation of green innovation is a necessary condition for achieving sustainable development in the modern era. Strengthening government policies, increasing investments, and developing the innovation ecosystem can be considered priority directions for future research and practical activities.

Recommendations

Based on the results of the study, the following recommendations are proposed to accelerate the widespread adoption of green innovation and ensure sustainable development:

1. Strengthen government support for green innovation- Purposeful programs should be developed by the government, and subsidies and tax incentives promoting the adoption of green technologies should be increased. At the same time, public-private partnership mechanisms should be expanded, and special funds established to finance innovative projects.
2. Provide incentives for innovation investments- Investment in research and development (R&D) activities should be increased, particularly supporting startup ecosystems and technology-based entrepreneurship. The development of the venture capital market and the creation of a favorable environment for investors can contribute to accelerating green innovation.
3. Enhance environmental regulatory mechanisms-The legislative framework for environmental protection should be updated to meet modern challenges, environmental standards should be tightened, and their enforcement strengthened. Economic instruments for reducing carbon emissions—such as carbon taxes, emission quotas, and other market-based mechanisms—should be implemented.
4. Expand international cooperation-Experience exchange with leading countries in the field of green innovation should be promoted, participation in international projects increased, and collaboration with global financial institutions strengthened. This will facilitate technology transfer and enhance innovation potential.
5. Strengthen education and awareness programs-To increase ecological awareness in society, education programs should include topics on green economy and sustainable development, and public awareness campaigns should be expanded. This will help foster sustainable consumption and production behaviors in the long term.
6. Ensure integration with digital technologies-To enhance the effectiveness of green innovation, integration with digitalization, artificial intelligence, and “smart” management systems should be strengthened. This approach will enable more precise resource management and improved energy efficiency.

Overall, the implementation of these recommendations will accelerate the development of green innovation, ensure the sustainability of economic growth, and make a significant contribution to environmental protection.

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The Impact of Medical Managers' Leadership Behaviors On Organizational Outcomes and Growth Indicators

Selami Yildirim

Abstract. *This study aims to examine the effects of medical managers' leadership behaviors on organizational outcomes and business growth indicators. The study analyzes transformational, transactional, and laissez-faire leadership. The study quantitatively analyzed the effects of behaviors on individual organizational outcomes such as extra effort, efficiency, and satisfaction, as well as growth indicators such as staff increase, revenue increase, and asset increase. Relationships between variables were tested using multiple regression analysis. The findings indicate that transformational leadership behaviors have strong and significant effects, particularly on individual outcomes related to employees. In this context, inspirational motivation and individual care dimensions were found to be the most decisive factors for extra effort, effectiveness, and satisfaction. In contrast, transactional leadership behaviors were found to be more effective, especially on organizational growth indicators such as personnel and revenue growth. However, laissez-faire leadership behaviors were found to have no significant effect on the variables examined. The findings reveal that leadership behaviors in healthcare organizations have varying degrees of impact on both employee performance and organizational growth; however, transformational leadership is more decisive in terms of sustainable organizational success. These findings indicate that leadership development should be considered a strategic priority in healthcare management practices.*
This study offers a unique contribution to the literature by examining leadership behaviors in conjunction with indicators of organizational growth.

Keywords: *leadership, transformational leadership, healthcare management, organizational performance, medical administrators*

Azerbaijan State University of Economics, Baku, Azerbaijan
E-mail: selami27tr@yahoo.com
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Tibbi menecerlərin liderlik davranışlarının təşkilati nəticələrə və böyümə göstəricilərinə təsiri

Selami Yıldırım

Xülasə. *Bu tədqiqat tibbi menecerlərin liderlik davranışlarının təşkilati nəticələrə və biznesin inkişaf göstəricilərinə təsirini araşdırmağı məqsəd qoyur. Tədqiqatda transformasional, tranzaksional və laissez-faire liderlik davranışlarının əlavə səy, effektivlik və məmnunluq kimi fərdi təşkilati nəticələrə, eləcə də işçi heyətinin artımı, gəlir artımı və aktivlərin artımı daxil olmaqla inkişaf göstəricilərinə təsiri kəmiyyət metodu ilə təhlil edilmişdir. Dəyişənlər arasındakı əlaqələr çoxsaylı reqressiya analizi vasitəsilə yoxlanılmışdır. Nəticələr göstərir ki, transformasional liderlik davranışları xüsusilə işçilərlə bağlı fərdi nəticələr üzərində güclü və əhəmiyyətli təsirə malikdir. Bu kontekstdə ilhamverici*

motivasiya və fərdi diqqət ölçülərinin əlavə səy, effektivlik və məmnunluq üzərində ən müəyyənedici amillər olduğu müəyyən edilmişdir. Bunun əksinə olaraq, tranzaksional liderlik davranışlarının təşkilati inkişaf göstəriciləri, xüsusilə işçi heyətinin və gəlirin artımı üzərində daha təsirli olduğu aşkar edilmişdir. Laissez-faire liderlik davranışlarının isə araşdırılan dəyişənlər üzərində əhəmiyyətli təsirə malik olmadığı müəyyən edilmişdir. Tədqiqatın nəticələri səhiyyə müəssisələrində liderlik davranışlarının həm işçi performansına, həm də təşkilati inkişafa müxtəlif səviyyələrdə təsir göstərdiyini ortaya qoyur; bununla belə, davamlı təşkilati uğur baxımından transformasional liderliyin daha müəyyənedici olduğu qənaətinə gəlinir. Bu nəticələr səhiyyə idarəçiliyi təcrübələrində liderliyin inkişaf etdirilməsinin strateji prioritet kimi nəzərdən keçirilməli olduğunu göstərir. Bu tədqiqat liderlik davranışlarını təşkilati inkişaf göstəriciləri ilə birlikdə araşdırmaqla ədəbiyyata özünəməxsus töhfə verir.

Açar sözlər: *liderlik, transformasional liderlik, səhiyyə idarəçiliyi, təşkilati performans, tibbi menecerlər*

Azərbaycan Dövlət İqtisad Universiteti, Bakı, Azərbaycan
E-poçt: selami27tr@yahoo.com
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© Müəllif(lər) 2026. Bu, Creative Commons Attribution-NonCommercial 4.0 Beynəlxalq Lisenziyası (CC BYNC 4.0) şərtləri altında paylanan açıq girişli məqalədir.

Introduction

Healthcare organizations are complex entities operating under high uncertainty, intense competition, and constantly changing environmental factors. Therefore, the effectiveness of healthcare services depends not only on technological infrastructure or financial resources but also on the quality of leadership behaviors (Bass & Avolio, 1994; Yukl, 2013). Leadership is a fundamental management function that directs employee motivation, commitment, and performance in achieving organizational goals. Transformational leadership, in particular, is gaining increasing importance in the healthcare sector because it motivates employees by exceeding their expectations and aligning them with the organizational vision (Bass, 1985). Transformational leaders encourage employees to exert extra effort and contribute to organizational outcomes through dimensions such as inspirational motivation, individual attention, intellectual stimulation, and idealized influence (Bass & Riggio, 2006). In healthcare organizations, leadership directly impacts not only employee performance but also patient satisfaction, service quality, and organizational effectiveness (Goleman, 2000). In this context, the leadership styles of medical administrators, in particular, play a critical role in the sustainability of healthcare services.

Literature shows that the transactional leadership approach is largely based on reward-punishment mechanisms; while it may improve performance in the short term, it is limited in its ability to promote long-term organizational commitment (Judge & Piccolo, 2004). In contrast, transformational leadership stands out because it increases employees' intrinsic motivation, leading to higher organizational commitment and performance. The theoretical basis of this study includes the laissez-faire leadership approach. This leadership style is often associated with low performance and uncertainty due to its minimal intervention in decision-making processes (Skogstad et al., 2007). Therefore, examining the impact of leadership behaviors on organizational outcomes in healthcare institutions has become a critical requirement from a strategic management perspective. Recent studies have shown that leadership behaviors in the healthcare sector affect not only individual performance but also macro-level outcomes such as organizational growth, revenue increase, and service capacity (West et al., 2014). Consequently, a multidimensional assessment of leadership styles makes a significant contribution to the healthcare management literature.

This study empirically examines the impact of medical administrators' leadership behaviors on organizational outcomes. Leadership has long been considered a key determinant of both individual performance and organizational effectiveness in the organizational behavior literature. In this context, the transformational leadership approach, in particular, has become a subject of extensive research due to its impact on increasing employee motivation, commitment, and performance (Bass, 1985; Bass & Riggio, 2006). Transformational leadership is an approach that guides employees not only to perform their duties but also to achieve higher performance aligned with the organizational vision.

Bass and Avolio (1994) and Avolio et al. (1999) demonstrated that transformational leadership has both direct and indirect effects on organizational performance (Avolio et al., 1999). This leadership style consists of four core dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individual attention. It is noted that the inspirational motivation dimension, in particular, plays a significant role in employees' willingness to exert extra effort (Podsakoff et al., 1990). One of the most important components of transformational leadership, individual attention, refers to meeting employees' needs and supporting their development. Yukl (2013) emphasizes that individual attention contributes to long-term organizational success by improving employees' competencies. Similarly, the intellectual stimulation dimension increases creativity within the organization by encouraging employees to think innovatively.

Burns (1978) defines transformational leadership as an ethical and visionary process, emphasizing the mutually transformative relationship between the leader and the followers. This approach implies that the leader assumes not only a guiding role but also a role in supporting the development of employees. On the other hand, transactional leadership exhibits a structure largely based on reward and punishment mechanisms. Judge and Piccolo (2004) state that transactional leadership can provide short-term performance improvements, but is limited in terms of sustainable motivation and organizational commitment. This leadership style aims to manage employee performance through control and rewards. The importance of leadership behaviors is even more pronounced in the healthcare sector. Wong and Cummings (2007) demonstrated that transformational leadership in healthcare organizations improves both employee satisfaction and the quality of patient care. Similarly, Goleman et al. (2002) noted that leadership based on emotional intelligence has significant effects on team cohesion and performance in healthcare.

Kouzes and Posner (2017) emphasize that effective leadership is associated with the ability to build trust, develop a shared vision, and engage employees in the process. In this context, leadership is seen not only as a management function but also as a strategic organizational capacity. However, in the literature, the laissez-faire leadership approach is generally associated with negative outcomes. In this leadership style, the leader's minimal intervention can lead to role ambiguity and poor performance (Skogstad et al., 2007). Therefore, the effectiveness of this leadership style in healthcare organizations is considered limited. Porter (1985) emphasizes the importance of leadership in the implementation of competitive strategies, while Tichy and Devanna (1986) define transformational leadership as the fundamental driving force of organizational change. On the other hand, Schein (2010) states that leadership is a decisive factor in the formation of organizational culture. Yukl and Van Fleet (1992) state that leadership behaviors exhibit a multidimensional structure and have different effects on various organizational outcomes. This underscores the importance of multivariate analyses in leadership research.

In conclusion, the literature shows that transformational leadership has strong effects on employee performance, organizational effectiveness, patient satisfaction, and innovation, especially in the healthcare sector. While transactional leadership tends to produce short-term results, laissez-faire leadership is often associated with negative organizational outcomes. Therefore, addressing leadership behaviors in a multidimensional way within healthcare organizations is considered a critical requirement for organizational success.

Theoretical Framework

3.1 The Concept of Leadership

Leadership is defined as the process of directing, motivating, and mobilizing individuals toward common goals to achieve organizational objectives (Burns, 1978). In this sense, leadership is seen not only as an authority-based management function but also as a process of interpersonal interaction and meaning-making. Modern leadership approaches view leadership as a dynamic process central to organizational behavior, explaining a leader's influence over employees through their capacity for transformation, motivation, and vision creation (Bass, 1985; Northouse, 2021).

3.2 Transformational Leadership

Transformational leadership is a leadership approach that aims to achieve organizational goals by increasing employee motivation (Bass & Avolio, 1994). This model consists of dimensions of idealized influence, inspirational motivation, intellectual stimulation, and individual attention (Bass & Riggio, 2006). Numerous studies have shown that transformational leadership in the healthcare sector has significant impacts on patient safety, employee satisfaction, and organizational commitment (Wong et al., 2013; Boamah et al., 2018). Furthermore, it has been noted that transformational leaders enhance the resilience of healthcare systems during times of crisis (Hargett et al., 2017; Cummings et al., 2018).

3.3 Transactional Leadership

Transactional leadership is a leadership approach based on reward-punishment mechanisms (Bass, 1990). While this leadership style is effective in terms of short-term performance control, it has limited effects on long-term motivation (Judge & Piccolo, 2004). In healthcare organizations, transactional leadership is primarily used in managing operational processes and maintaining standards (Giltinane, 2013). However, it is also noted that overly controlling transactional approaches can increase employee burnout (Laschinger et al., 2013).

3.4. Laissez-Faire Leadership

Laissez-faire leadership is a passive leadership style in which the leader intervenes minimally in decision-making processes (Bass & Avolio, 1994). This leadership approach has been associated with low performance, low job satisfaction, and weak organizational commitment in most studies (Judge & Piccolo, 2004; Skogstad et al., 2007). In the healthcare sector, laissez-faire leadership is considered a factor that negatively impacts patient safety, especially in high-risk environments (Aarons et al., 2014).

3.5 Leadership in the Healthcare Sector

Leadership is defined as the process of directing individuals toward common goals and plays a critical role in healthcare organizations in terms of service quality, patient safety, and employee performance (Northouse, 2021; Yukl, 2013). In the healthcare sector, leadership is not only a management function but also a strategic element that shapes organizational culture (Giltinane, 2013). Due to their complex structures, healthcare organizations must adapt to constantly changing environmental conditions. Therefore, leadership is considered a key determinant in enhancing organizational effectiveness (Boamah et al., 2018; Figueroa et al., 2019). In particular, leadership behaviors in nursing and medical management directly affect employee commitment and patient outcomes (Wong & Cummings, 2007).

Research Objective

The main objective of this study is to examine the effects of leadership behaviors of medical managers on organizational outcomes using a holistic approach. In this context, the study investigates transformational leadership, transactional leadership, and laissez-faire leadership behaviors.

- the effects of extra effort on organizational outcomes such as efficiency and satisfaction;
- and their relationships with growth indicators representing business performance, such as employee numbers, revenue, and asset increases.

In this context, the research aims to evaluate not only the behavioral consequences of different leadership styles among medical administrators at the individual and organizational levels, but also their potential impact on the growth performance of the institutions.

4.1 Research Hypotheses

Based on the theoretical framework and previous empirical findings, this study tested the following hypotheses. These hypotheses were formulated to examine the effects of transformational, transactional, and laissez-faire leadership behaviors on both employee-related organizational outcomes and business growth indicators.

H1: Transformational leadership behaviors have a statistically significant positive effect on extra effort.
H2: Transformational leadership behaviors have a statistically significant positive effect on perceived effectiveness.
H3: Transformational leadership behaviors have a statistically significant positive effect on job satisfaction.
H4: Transactional leadership behaviors have a statistically significant effect on employee growth.
H5: Transactional leadership behaviors have a statistically significant effect on revenue growth.
H6: Leadership behaviors have a statistically significant effect on asset growth.
H7: Laissez-faire leadership behaviors have a statistically significant negative or unsupportive effect on organizational outcomes and growth indicators.

Methods

This study is a quantitative research conducted to examine the effects of medical managers' leadership behaviors on organizational outcomes. A correlational survey model was used in the study, and the relationships between variables were tested using multiple regression analysis. This approach allows for the evaluation of the effects of independent variables on dependent variables within the same model (Field, 2013).

Sampling and Data Collection

The study sample consisted of a total of 148 medical device managers working in Ankara. Data were collected using the Multifactor Leadership Questionnaire (MLQ 5X Short Form) developed by Bass and Avolio (1995) to measure leadership behaviors. This scale evaluates leadership behaviors across three core dimensions: transformational, transactional, and laissez-faire leadership. The scale consists of 45 items, and participants respond to each statement using a 5-point Likert scale ranging from 0 (never) to 4 (always). In addition, the data collection tool includes questions about variables such as gender and seniority to determine the demographic characteristics of the participants.

Sampling Method and Participant Profile

The research population consisted of managers working in medical device companies and related healthcare organizations operating in Ankara. The sample included 148 medical managers with management responsibility and experience in organizational decision-making processes. Participants were selected using a non-probability purposive sampling method, as the study specifically targeted managers with direct knowledge of leadership practices and organizational outcomes in the medical device sector. Medical device manufacturers, distributors, and importers were included in the study.

Table 1
Demographic Characteristics of Medical Device Managers

Variable	Category	N	%
Gender	Woman	25	16.90
	Male	123	83.10
Age	Under 25	7	4.70
	20-29	12	8.10
	30-34	25	16.90
	35-39	36	24.30
	40-44	31	20.90
	45-49	25	16.90
	50 and over	12	8.10
Service Period	1-5 years	19	12.80
	6-10 years	68	45.90
	11-15 years old	36	24.30
	16 years and older	25	16.90

Table 1 presents the demographic characteristics of the 148 medical device managers who participated in the study. Examining the gender distribution, it is seen that the vast majority of participants are male. Male participants constitute 83.10% of the total sample, while female participants make up 16.90%. This indicates that the research sample has a predominantly male gender structure. When evaluated in terms of age, it is observed that medical device managers are most concentrated in the 35-39 age range. Participants in this age group constitute 24.30% of the total sample. This is followed by the 40-44 age group with 20.90%. Furthermore, the 30-34 and 45-49 age groups are each represented at 16.90%. These findings indicate that the research sample consists predominantly of middle-aged individuals. In contrast, the proportion of participants under 25 years of age is quite low at 4.70%.

When examined in terms of length of service, it was determined that the largest proportion of medical device managers had 6-10 years of professional experience. The 68 participants in this group constituted 45.90% of the total sample. This was followed by participants with 11-15 years of service at 24.30%. Furthermore, the proportion of participants with 16 years or more of experience was 16.90%, while the proportion of participants with 1-5 years of experience was 12.80%. These results reveal that the sample consists largely of individuals with significant professional experience. Overall, the research sample can be described as predominantly male, mostly middle-aged medical device managers with over six years of experience. This demographic structure suggests that the study findings may reflect the views of experienced and middle-aged male participants more accurately. Therefore, the imbalance in gender distribution and the experience level of the sample should be considered when interpreting the research results.

Variables

The independent variables of the study are the dimensions of leadership behavior. In this context:

- Transformational leadership (idealized influence, inspirational motivation, intellectual stimulation, and individual attention),
- Transactional leadership (contingent reward, active management-by-exception, and passive management-by-exception),
- Laissez-faire leadership

It has been analyzed.

The dependent variables of the study were examined under two main groups:

- Organizational outcomes at the individual level: Extra effort, efficiency, and satisfaction.
- Organizational growth indicators: Increase in personnel, increase in revenue, and increase in assets.

Through this framework, the effects of leadership behaviors on both employee performance and organizational growth have been evaluated using a holistic approach.

Data Analysis

Multiple regression was used to analyze the research data. This method allows testing the effects of multiple independent variables on dependent variables within the same model (Hair et al., 2010). In the analysis process, the overall significance of the model was evaluated using the F-test, while the individual effects of the independent variables were examined using t-tests. Furthermore, the coefficient of determination (R^2) was considered when determining the explanatory power of the model. Through the models developed within this context, the relative effects of transformational, transactional, and laissez-faire leadership behaviors on organizational outcomes have been analyzed comparatively.

Reliability and Validity

The Multifactor Leadership Questionnaire (MLQ 5X Short Form) used in this study is a widely used and validated scale for assessing leadership behaviors (Bass & Avolio, 1995). Reliability analyses of the subscales were evaluated using the Cronbach's Alpha coefficient. The analysis results showed that both the overall scale and its subscales had Cronbach's Alpha values above acceptable thresholds ($\alpha > 0.70$). These findings indicate that the measurement instrument used is reliable in terms of internal consistency. Furthermore, the scale's construct validity is supported by previous studies in the literature, which strengthens the validity of the research findings.

Ethical Considerations

This study was conducted in accordance with the principles of scientific research and publication ethics. Participants were informed about the purpose of the study during the data collection process, and voluntary participation was prioritized. Data obtained from participants were evaluated anonymously, and confidentiality was observed. Throughout the research process, no situation arose that would harm the interests of any individual or institution; the data was used solely for scientific purposes.

Findings

This section presents the findings of a regression analysis of the effects of medical managers' leadership behaviors on organizational outcomes. Transformational leadership, transactional leadership, and laissez-faire leadership were considered as independent variables in the analysis. Dependent variables were defined as extra effort, effectiveness, satisfaction, and business growth indicators (staff growth, revenue growth, and asset growth). These results are presented in Tables 2 and 3 below.

Table 2
Multiple Regression Analysis Model Summaries

Dependent variable	F	p	R^2	Adjusted R^2	Model result
Extra effort	13,583	<0.001	0.515	Unspecified	The model is meaningful.
Effectiveness	14,608	<0.001	0.533	Unspecified	The model is meaningful.
Satisfaction	7,049	<0.001	0.356	Unspecified	The model is meaningful.
Increase in the number of staff	2,015	<0.05	0.137	Unspecified	The model is meaningful.
Increase in business revenues	4,644	<0.05	0.265	Unspecified	The model is meaningful.
Increase in business assets	-	>0.05	-	-	There is no significant effect in the model.

Table 3
Significant Predictor Variables in Regression Analyses

Dependent variable	Significant independent variable	B	SH	β	t	p	Comment
Extra effort	Inspirational motivation	0.542	0.130	0.500	4,160	0.000	Positive and significant impact.
Effectiveness	Idealized cause-and-effect	0.347	0.119	0.295	2,918	0.004	Positive and significant impact.
Effectiveness	Inspirational motivation	0.413	0.124	0.391	3,320	0.001	Positive and significant impact.
Effectiveness	Individual attention	0.227	0.111	0.189	2,041	0.044	Positive and significant impact.
Satisfaction	Inspirational motivation	0.428	0.142	0.417	3,013	0.003	Positive and significant impact.
Satisfaction	Individual attention	0.314	0.127	0.270	2,478	0.015	Positive and significant impact.
Increase in the number of staff	Active management-by-exception	-0.528	0.183	-0.276	-2,877	0.005	Negative and significant impact
Increase in business revenues	Active management-by-exception	0.457	0.125	0.322	3,649	0.000	Positive and significant impact.

Dependent variable	Significant independent variable	B	SH	β	t	p	Comment
Increase in business revenues	Passive management-by-exception	-0.457	0.153	-0.352	-2,991	0.003	Negative and significant impact.
Increase in business assets	There are no significant variables.	—	—	—	—	>0.05	Leadership behaviors had no significant effect.

6.1 Extra Effort

Regression analysis performed on the extra effort variable revealed that only the inspirational motivation dimension had a statistically significant effect ($p < 0.001$). The explanatory power of the model was calculated as $R^2 = 51.5\%$. This finding indicates that transformational leadership, particularly its inspirational motivation dimension, plays a decisive role in encouraging employees to exert extra effort beyond their normal job descriptions. In contrast, transactional leadership and laissez-faire leadership dimensions were not found to have a significant effect on extra effort.

6.2 Effectiveness

The regression analysis results for the effectiveness variable revealed that transformational leadership dimensions such as idealized influence-behavior, inspirational motivation, and individual attention exhibited significant effects. The explanatory power of the model was calculated as $R^2 = 53.3\%$. These results show that employees' perception of organizational effectiveness is directly related to the leader's role model behavior, their ability to motivate employees, and the importance they place on employees' individual development. Transactional leadership or laissez-faire leadership variables did not have a statistically significant effect on effectiveness.

6.3 Job Satisfaction

Analyses of the job satisfaction variable revealed that the dimensions of inspirational motivation and individual care had significant effects. The explanatory power of the model was calculated as $R^2 = 35.6\%$. These findings reveal that employee satisfaction is particularly related to the leader's motivational approach and the individual attention the leader shows to employees. In contrast, transactional leadership and laissez-faire leadership behaviors were not found to have a significant effect on satisfaction.

6.4 Growth Indicators

Analysis of business growth indicators reveals that the effects of leadership dimensions vary.

- Only the “active management-by-exception” (transactional leadership) dimension was found to have a significant impact on workforce growth. This result indicates that an active management approach, which relies more on performance control, is associated with organizational expansion processes. The “laissez-faire leadership” and “transformational leadership” dimensions were found to be insignificant.
- However, in terms of revenue growth, both active management-by-exception and passive management-by-exception dimensions were found to have significant effects. This finding ( ) indicates that transactional leadership is particularly decisive in terms of financial performance indicators. Laissez-faire leadership was not found to have a significant effect on this variable.

- Regarding the asset growth variable, it was found that none of the dimensions of transformational leadership, transactional leadership, or laissez-faire leadership had a statistically significant effect.

6.5 Overall Assessment

Overall, the findings indicate that transformational leadership behaviors have a stronger impact, particularly on employees' individual and motivational outcomes (extra effort, effectiveness, satisfaction). In contrast, transactional leadership behaviors were found to be more effective on organizational growth indicators (especially personnel and revenue increases), while laissez-faire leadership behaviors showed no significant effect on any dependent variable.

Discussion

This study examines the effects of medical administrators' leadership behaviors on employee outcomes (extra effort, effectiveness, and satisfaction) and organizational growth indicators (increases in staff, revenue, and assets). The findings reveal strong and significant relationships, particularly between transformational leadership dimensions and employee outcomes. These results are largely consistent with classical and contemporary studies in the leadership literature (Bass, 1985; Bass & Avolio, 1994; Judge & Piccolo, 2004).

Transformational Leadership and Employee Outcomes

According to the research findings, only the inspirational motivation dimension has a significant effect on extra effort. This finding supports the view put forward by Bass and Riggio (2006), that inspirational behavior, a key component of transformational leadership, facilitates extra effort by increasing employees' intrinsic motivation. Similarly, Podsakoff et al. (1990) emphasize that inspirational leadership behaviors play a critical role in helping employees develop voluntary commitment to organizational goals. Furthermore, Bass and Avolio (1994) state that transformational leadership enhances employee performance, particularly through “meaning creation” and “vision communication.” In this context, medical managers setting clear, understandable, and motivating goals can be considered a fundamental mechanism explaining why healthcare professionals exert extra effort.

Effects on the Event

The finding that idealized influence-behavior, inspirational motivation, and individual attention have significant effects on the effectiveness variable is consistent with findings in the literature. Bass and Avolio (1994) state that transformational leadership creates performance improvements, especially by helping employees internalize organizational goals. Furthermore, Northouse (2021) emphasizes that individual attention is one of the most important leadership behaviors that enhances organizational effectiveness by supporting employee development. Studies, particularly in the healthcare sector, support these findings. Cummings et al. (2018) demonstrated that transformational leadership in nursing and health management has positive effects on patient outcomes and employee performance. Similarly, Aiken et al. (2008) state that the quality of leadership in healthcare organizations is directly related to the quality and effectiveness of services (Aiken et al., 2008).

Job Satisfaction and Leadership Behaviors

According to the research results, employee satisfaction is significantly influenced by inspiring motivation and individual attention. This finding is consistent with Herzberg's two-factor theory and the literature on job satisfaction. According to Herzberg, one of the most important factors that increases employee satisfaction is the manager's supportive and development-oriented behavior.

Goleman (1998) states that in leadership approaches based on emotional intelligence, supporting employees individually increases organizational commitment and job satisfaction. Similarly, McAlearney (2006) emphasizes that individual support and mentoring approaches play a critical role in employee commitment and satisfaction in healthcare organizations.

Transactional Leadership and Limited Effects

The study revealed that the dimensions of transactional leadership (particularly contingent reward and management-by-exception) have limited effects on most variables. This finding is consistent with the classic distinction made by Bass (1985). According to Bass, transactional leadership relies more on short-term performance control and reward-punishment mechanisms, while transformational leadership promotes more sustainable behavioral change. Yukl (2013) also notes that transactional leadership is particularly effective in routine tasks, but has limited effects on innovation, commitment, and long-term performance. This is logical given the nature of the healthcare sector, which involves high uncertainty and complexity.

Organizational Growth Indicators

The study revealed that certain dimensions of transactional leadership have significant effects on employee growth and revenue increase. Specifically, the influence of active management-by-exception behavior on these two variables suggests that control-oriented leadership behaviors may have short-term effects on operational growth. Mintzberg (1973) notes that management control mechanisms in organizations can support structural expansion, especially during periods of growth. However, the fact that no single leadership behavior has a significant impact on asset growth suggests that growth is not always directly related to leadership behavior, and that financial and environmental factors may be more decisive. A broader interpretation of the asset growth finding is important. Asset growth is generally a long-term and capital-intensive indicator and may depend more on external financing conditions, investment decisions, market demand, regulatory processes, technology acquisition, and corporate ownership structure than on the immediate leadership behavior of managers. Therefore, the absence of a statistically significant leadership effect on asset growth should not be interpreted as leadership being unrelated to organizational development. Rather, it suggests that leadership can indirectly influence asset growth over a longer period through employee performance, service quality, revenue generation, and strategic decision-making. Since the current study is cross-sectional, it may not fully capture these lagged or mediated effects. Future studies should examine asset growth using longitudinal data and include additional financial and environmental control variables.

General Assessment in the Context of the Healthcare Sector

Healthcare organizations operate under conditions of high environmental uncertainty, regulatory pressure, and competition (Shortell & Kaluzny, 2006). Consequently, the impact of leadership behaviors becomes more critical compared to other sectors. West et al. (2015) emphasize that leadership in healthcare organizations has a direct impact on patient safety, employee motivation, and service quality. The findings of this study demonstrate that transformational leadership stands out as a strategic management tool, particularly in the healthcare sector. Specifically, inspirational motivation and personalized attention emerge as the most critical factors for both employee performance and organizational success. This study offers a comprehensive and original contribution to the literature by examining leadership behaviors not only in relation to individual organizational outcomes but also to business growth indicators.

Conclusions and Recommendations

Conclusion

This research aimed to examine the effects of medical administrators' leadership behaviors on organizational outcomes and job performance. The findings reveal that leadership dimensions have varying degrees of impact on organizational outcomes. According to the research results, transformational leadership style exhibits stronger and more significant effects, particularly in terms of outcomes related to employee behavior. In this context, inspirational motivation, a sub-dimension of transformational leadership, emerged as the strongest and most consistent predictor of both extra effort and the variables of effectiveness and satisfaction. In contrast, the effects of transactional leadership dimensions were found to be more limited and particularly associated with short-term performance indicators. It was observed that transactional leadership only had an impact on specific growth indicators (staff and revenue increases), but did not significantly contribute to overall organizational effectiveness and employee satisfaction. Furthermore, it was found that laissez-faire leadership behaviors had no significant effect on any of the dependent variables analyzed. This result indicates that a leader's lack of intervention in guidance and decision-making processes plays an ineffective or limiting role in terms of organizational performance. Overall, research findings indicate that leadership behaviors in healthcare organizations play a decisive role in organizational outcomes, and that transformational leadership, in particular, is more effective in terms of sustainable performance. This study, which analyzes leadership behaviors in conjunction with organizational growth indicators, expands on a limited area in the literature and provides a unique contribution to the field of health management.

Suggestions

Based on the research findings, the following recommendations have been developed for healthcare organizations and managers:

Transformational leadership development:

Leadership training programs for managers in healthcare organizations should prioritize transformational leadership skills (inspiring, providing individual attention, and developing vision). Such training will play a critical role in increasing employee motivation and organizational commitment.

Management focused on individual development:

Managers who adopt a leadership approach sensitive to the individual needs of employees will increase both employee satisfaction and organizational effectiveness. Therefore, leadership practices focused on individual development should be institutionalized as corporate policy.

Integration of strategic management:

Leadership development should be integrated into the strategic management processes of healthcare organizations. Aligning leadership competencies with organizational growth objectives is crucial for long-term sustainable success.

The supportive use of transactional leadership:

Transactional leadership should not be completely excluded, but rather used as a supportive tool in performance management and operational control processes.

Avoiding laissez-faire leadership:

Since laissez-faire leadership behaviors are associated with organizational uncertainty and poor performance, it is recommended that this leadership style be minimized in healthcare organizations.

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Dünya iqtisadiyyatında enerji siyasəti və maliyyə resurslarının səfərbər edilməsinin iqtisadi əsasları

Dağbəyi Allahverdiyev[1*], Əli Allahverdiyev[2], Nigar Allahverdiyeva[2], Günel Allahverdiyeva[3], Güldanə Qasımova[3]

Xülasə. *Tədqiqatda müasir qlobal siyasi-iqtisadi şəraitdə bərpa olunan enerji siyasətinin inkişaf istiqamətləri və bu sahədə maliyyə resurslarının səfərbər edilməsinin iqtisadi əsasları təhlil edilir. Davamlı iqtisadi artımın təmin olunmasında bərpa olunan enerji mənbələrinin rolu və investisiya prioritetlərinin sabit iqtisadi siyasət əsasında yenidən müəyyənləşdirilməsi mühüm əhəmiyyətə malikdir. Bərpa olunan enerji siyasəti yalnız ekoloji baxımdan deyil, eyni zamanda makroiqtisadi sabitliyin təmin olunması, enerji təhlükəsizliyinin gücləndirilməsi və uzunmüddətli iqtisadi artımın formalaşdırılması baxımından strateji əhəmiyyətə malikdir.*

Metodologiya: bu tədqiqatda dünya iqtisadiyyatında enerji siyasətinin və maliyyə resurslarının səfərbər edilməsinin iqtisadi əsaslarının təhlili kompleks metodoloji yanaşma əsasında həyata keçirilmişdir. Tədqiqatın metodoloji bazasını iqtisadi nəzəriyyənin klassik və müasir yanaşmaları, həmçinin beynəlxalq təcrübə təşkil edir.

Tədqiqatın obyekti və predmeti: Tədqiqatın obyekti qlobal enerji siyasəti və bərpa olunan enerji sahəsində mövcud iqtisadi proseslərdir.

Tədqiqatın predmeti isə bərpa olunan enerji siyasəti çərçivəsində maliyyə resurslarının səfərbər edilməsinin iqtisadi mexanizmləri, bu prosesin makroiqtisadi sabitliyə və davamlı iqtisadi artıma təsiridir.

Tədqiqat metodları: Tədqiqat prosesində aşağıdakı elmi metodlardan istifadə olunmuşdur:

Analiz və sintez metodu, enerji siyasəti və maliyyə mexanizmlərinin ayrı-ayrı komponentlərinin təhlili və ümumiləşdirilməsi üçün tətbiq edilmişdir;

Müqayisəli təhlil metodu, müxtəlif ölkələrin enerji siyasəti və investisiya göstəricilərinin müqayisəsi məqsədilə istifadə olunmuşdur;

Statistik təhlil metodu, qlobal enerji investisiyaları və maliyyə meyarlarının qiymətləndirilməsi üçün tətbiq edilmişdir;

Sistemli yanaşma metodu, enerji siyasəti, maliyyə resursları və iqtisadi artım arasında qarşılıqlı əlaqələrin kompleks şəkildə araşdırılmasını təmin etmişdir.

İnformasiya bazası: Tədqiqatın informasiya bazasını beynəlxalq təşkilatların hesabatları, rəsmi statistika məlumatları, elmi ədəbiyyat və müxtəlif analitik mənbələr təşkil edir. Eyni zamanda, cədvəllərdə təqdim olunan məlumatlar rəsmi statistik göstəricilər əsasında müəllif tərəfindən ümumiləşdirilmişdir.

Açar sözlər: *enerji siyasəti, bərpa olunan enerji, maliyyə resursları, davamlı iqtisadi artım, iqtisadi inkişaf, insan rifahı*

[1]ARETN-in İqtisadiyyat İnstitutu, iqtisad üzrə fəlsəfə doktoru, Bakı, Azərbaycan
[2]Bakı Dövlət Universiteti, Bakı, Azərbaycan
[3]Bakı Dövlət Universiteti, magistrant, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: dagbeycahani@gmail.com
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Energy Policy in the World Economy and the Economic Foundations of Mobilizing Financial Resources

Dagbey Allahverdiyev[1*], Ali Allahverdiyev[2], Nigar Allahverdiyeva[2], Gunel Allahverdiyeva[3], Guldana Gasimova[3]

Abstract. *This study examines the development directions of renewable energy policy and the economic foundations of mobilizing financial resources in the context of the modern global political and economic environment. The research highlights the growing importance of renewable energy as a key factor in ensuring sustainable economic growth, macroeconomic stability, and long-term energy security. In the context of increasing geopolitical risks and climate change challenges, the transformation of global energy policy has become inevitable. The transition to renewable energy sources is not only an environmental necessity but also an economic priority that contributes to reducing external energy dependence, stabilizing balance of payments, and enhancing investment efficiency.*

The study emphasizes that the mobilization of financial resources plays a crucial role in supporting renewable energy projects through innovative financial instruments, including green bonds, climate funds, and public-private partnerships. These mechanisms facilitate the allocation of capital toward environmentally sustainable and economically efficient sectors.

Furthermore, the research analyzes the role of state regulation, fiscal policy, and institutional frameworks in ensuring effective financial mobilization and sustainable economic development. It is argued that the integration of economic, legal, and political factors strengthens the overall impact of energy policy on social welfare and economic stability.

The findings suggest that renewable energy policy, supported by efficient financial mechanisms, significantly contributes to sustainable development by improving economic resilience, fostering innovation, and ensuring environmental balance.

Keywords: *renewable energy policy, financial resources, sustainable economic growth, green finance, energy security, economic development*

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[1]ARETN Institute of Economics, PhD in Economics, Baku, Azerbaijan
[2]Baku State University, Baku, Azerbaijan
3Azerbaijan University of Architecture and Construction, Master's student, Baku, Azerbaijan
[*]Corresponding author. E-mail: dagbeycahani@gmail.com
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Giriş

Siyasi-iqtisadi səmərəliliyin təmin olunmasını şərtləndirən meyarların və proseslərin tarazlığı mühüm sosial əhəmiyyətə malikdir və müxtəlif nəzəri metodlar vasitəsilə təhlil olunur. Müasir şəraitdə sosial-iqtisadi münasibətlərin tənzimlənməsinin siyasi, iqtisadi və hüquqi əsasları alternativ maliyyə resurslarının səmərəli istifadəsi ilə əlaqədardır. Belə ki, sosial-iqtisadi mülkiyyət münasibətlərinin və bərpa olunan enerji təminatının tənzimlənməsi dövlətin siyasi-iqtisadi kontekstində optimal həlli əsasında balanslaşdırılmalıdır. İqtisadiyyatın dövlət tərəfindən tənzimlənməsi hələ qədim dövrlərdən etibarən cəmiyyətin diqqət mərkəzində olmuş, gəlir bərabərliyi və makroiqtisadi tarazlıq kimi meyarlar əsasında qiymətləndirilmişdir (Allahverdiyev, 2022). İqtisadi bərabərliyin təmin edilməsində bərpa olunan enerji siyasəti maliyyə tarazlığı əsasında iqtisadi artım kontekstində tədqiqi dünyanın geosiyasi reallıqlarının zərurətindən qaynaqlanır. Belə ki, mövcud qlobal iqtisadi siyasət XXI əsrdə bərpa olunan enerji təminatının əsas mərhələsini əks etdirir. Bu kontekstdə geosiyasi

risklər və iqlim dəyişiklikləri ilə bağlı çağırışlar enerji siyasətinin yenidən formalaşdırılmasını zəruri etmişdir (Nuriyev, 2021).

Nəticə etibarilə, bərpa olunan enerji siyasəti maliyyə səmərəliliyinin tərəqqisi iqtisadi artımda yeni modelini formalaşdırır. Qlobal enerji siyasətində alternativ maliyyə mənbələrinin davamlı artıma təsiri dövlət büdcəsi və investisiya siyasətinin prioritet istiqamətləri ilə müəyyən edilir. Bu səbəbdən də bərpa olunan enerji siyasətində davamlı tərəqqinin iqtisadi əsasları və maliyyə resurslarının səfərbər edilməsinin iqtisadi əsaslarının elmi və praktiki cəhətdən şərhi aktualdır.

Nəzəri yanaşmalar və əsas istiqamətlər isə bərpa olunan enerji siyasətində maliyyə təminatı mərhələli həyata keçirilir. Davamlı iqtisadi tərəqqi, BMT tərəfindən qəbul edilmiş Davamlı İnkişaf Məqsədləri bərpa edilən enerji təminatına əlçatanlığı və iqlim sabitliyinin qorunması prioritet hesab edilir. Bərpa olunan enerji siyasəti davamlı iqtisadi artım əsasında ekoloji balansın optimal tarazlıq nəticəsində formalaşır. Bərpa olunan enerjiyə təminatı, iqtisadi siyasətdə innovasiya nəticəsində mərhələli formada yeni bərpa edilən enerji tarazlığını ifadə edir. Bu proses kapitalın istehsal dövrüyəsi əsasında və investisiya siyasətinin tənzimlənməsi ilə maliyyə səmərəliliyində sosial-iqtisadi rifahı şərtləndirir. Yaşıl maliyyə siyasəti nəticəsində formalaşmış yaşıl maliyyə konsepsiyası ekoloji yönümlü layihələrin maliyyələşdirilməsi üçün alternativ maliyyə alətlərinin tətbiqini şərtləndirir. Yaşıl istiqrazlar, iqlim fondları və digər maliyyə alətləri vasitəsilə ekoloji layihələrin maliyyələşdirilməsi təmin edilir.

Davamlı iqtisadi artım anlayışı iqtisadi nəzəriyyənin müxtəlif mərhələlərində fərqli formada şərh edilmişdir. A. Marşal və digər tədqiqatçılar iqtisadi artımı əsasən kapital yığımı ilə əlaqələndirsə də, müasir dövrdə bu proses, sərvətin yenidən cəmlənməsi daha kompleks xarakterlidir (Marşal, 1993).

Mövcud geosiyasi-iqtisadi şəraitə uyğun olaraq iqtisadi artımın əsas meyarları qeyd edilir:
1. İnsan kapitalının tərəqqi zərurəti;
2. Maliyyə effektivliyi;
3. Dövlətin innovasiya siyasətinin insan tərəqqisində əhəmiyyəti və sosial rifaha təsiri ;
4. Dövlət və özəl sahənin əməkdaşlığı insan rifahına və sosial tərəqqini şərtləndirir.
5. İqtisadi artım yalnız kəmiyyət göstəriciləri ilə deyil, həm də iqtisadi siyasətin keyfiyyət meyarları ilə müəyyən edilir.

İqtisadi artımın davamlı xarakteri yalnız kəmiyyət göstəricilərinin artımı ilə deyil, iqtisadi siyasətin keyfiyyət meyarı ilə müəyyən edilir. Beləliklə, bərpa olunan enerji təminatının illərlə müqayisəli təhlili (cədvəl 1) təqdim edilir.

Cədvəl 1
Qlobal enerji siyasətinin müqayisəli təsviri (milyard $)

İl	Fosil sektor	Bərpa olunan enerji	Yaşıl iqtisadiyyat
2010	900	330	45
2016	955	475	113
2020	700	520	277
2025	659	627	519

Mənbə: Müəllif tərəfindən statistik məlumatlar əsasında tərtib edilmişdir.

Bərpa olunan enerji investisiyaları 2010–2025 dövründə təxminən bir qədər dəfə artmışdır. Yaşıl istiqraz və iqlim fondlarının əhatəliliyi maliyyə siyasətində yeni kapitalın formalaşmasına səbəb olmuşdur (Həbibbəyli, 2022). Kapital siyasətinin istiqaməti isə davamlı sosial-iqtisadi artımı şərtləndirmişdir.

Beləliklə, iqtisadiyyatın dövlət tənzimlənməsi əsasən davamlı sosial-iqtisadi rifah artımı ilə balanslaşır. İqtisadi qərarlar qəbul edərkən, dövlət bu qərarların siyasi-iqtisadi məqsədi maliyyə sabitliyi və alternativ maliyyə mənbələrinin intensivliyinin proqram təminatının tənzimlənməsi zəruridir (Nuriyev, 2021). Belə ki, iqtisadiyyatın tənzimlənməsi dövlətin mühüm funksiyalarından biri olmaqla, bazar iqtisadiyyatı şəraitində mənfi nəticələri aradan qaldırmaq, iqtisadi sferanı daha optimal idarə etmək və iqtisadi tərəqqini təmin etmək məqsədlərini özündə əks etdirir. Bu sahədə büdcə, bank sistemlərinin hüquqi, siyasi-iqtisadi sabitliyə təsiri ilə müəyyən edilir. Təbii ki, hüquq və iqtisadiyyat bir-biri ilə əlaqəli bir elm istiqamətdir. Belə ki, hələ qədim dövrdən hüquq və iqtisadiyyatın qarşılıqlı əlaqəsi ictimai inkişafın ümumi qanunauyğunluqlarına tabe olmaqla bir tərəfdən cəmiyyətin iqtisadi tələbatları obyektiv olaraq iqtisadi münasibətlərin tənzimlənməsinin hüquqi formalarının və müxtəlif mülkiyyət formalarının mühafizəsinə əsaslanırdı. Beləliklə, istehsalçıların müstəqilliyinin təmin edilməsinin zəruriliyi, digər tərəfdən iqtisadi münasibətlərin hüquqi forması ancaq ehtiyacdan ibarət deyildir, intensiv sosial-iqtisadi rifaha və siyasi-iqtisadi proseslərin vacib komponenti kimi səciyyələnir.

Davamlı iqtisadi artımın konseptual əsasları. Davamlı iqtisadi artım anlayışı iqtisad elminin müxtəlif mərhələlərində fərqli interpretasiyalara məruz qalmışdır. Bəzi iqtisadçılar iqtisadi artımı əsasən kapital yığımı ilə əlaqələndirmişlər. Lakin müasir dövrdə iqtisadi artım daha əhatəli kompleks xarakterə malikdir. Belə ki, neoklassik artım nəzəriyyələrində innovasiyalı tərəqqi iqtisadi artımın ekzogen amili kimi qəbul edilmişdir. Lakin müasir endogen artım nəzəriyyələri innovasiyalı iqtisadi sistemi formalaşdıran proses kimi qiymətləndirir.

Mövcud davamlı iqtisadi artıma yanaşmalara əsasən sosial artımın əsas meyarları aşağıdakılardır:

1. İnsan kapitalının keyfiyyət səviyyəsi,
2. Dövlətin innovasiya siyasətinin sosial rifaha təsiri,
3. Maliyyə təminatında effektik,
4. Dövlət və özəl sahənin əməkdaşlığı.

İqtisadi artımın davamlı artımı kəmiyyət meyarları ilə müəyyənləşmir, iqtisadi strukturun insan rifahının keyfiyyəti əsasında müəyyən edilir.

İqtisadiyyatın hüquqi tənzimlənməsinə müasir yanaşmalar. Bu kontekstdə, obrazlı qeyd etsək "İqtisadi fəaliyyət bir gəmiyə bənzəyir, sükanı idarə edən dövlətdirsə, yelkəni hərəkətə gətirən maddi maraqdır", iqtisadiyyat elmi davamlı sosial-iqtisadi artım rifahını şərtləndirir (Allahverdiyev, 2022).

İqtisadi fəaliyyətlər, istehsal münasibətlərindən istehlak münasibətlərinə qədər təkrar istehsalın bütün istiqamətləri əhatə edir və hüquq-siyasi münasibətləri də tənzimləyir. İqtisad elmi əsasən təbii ehtiyatlardan, istehsal vasitələrindən səmərəli istifadə etməklə, insanların rifahının ən optimal artımının təmin edilməsidir. Bu vəzifəni isə təkrar istehsalın bütün meyarlarına, istehsal, mübadilə və istehlaka dövlət dəstəyi əsasında reallaşa bilər. İqtisad elmi iqtisadi fəaliyyətin bütün sahələrini müşahidə edib araşdıraraq bazar iqtisadiyyatının təməl qanunlarını təyin etməyə çalışır. Yəni "olanı" daha doğrusu mövcud siyasi-iqtisadi şəraiti müşahidə edir və təyin edir. Bu səbəbdən də, fundamental elm sahə kimi iqtisad elmi tərəqqi mövqeindədir (Əlirzayev, 2022).

Belə iqtisadi sistemə 1960-cı ildə ictimai xərclərə dair araşdırmalar həm iqtisadi həm də sosial cəhətdən yüksək qiymətləndirilir. İctimai məsrəflər nəzəriyyəsinin məzmununda ən əhəmiyyətli məqamlar, haqsız rəqabəti şərh edir və sosial-iqtisadi artımı isə siyasi sabitliyin əsası hesab edir. Sosial-iqtisadi rifahın ən mühüm prinsip davamlı artım prinsipidir, əsas məqsəd isə "istehsal dəyərini" yüksəltməkdir (Əliyev, 2019). Beləliklə, qlobal iqtisadi siyasətin davamlı iqtisadi artım konsepsiyası müasir iqtisad elminin əsas tədqiqatını təşkil edir (Məmmədov, 2022a). Davamlı iqtisadi artım əsasən makroiqtisadi meyarların yüksəldilməsi deyil, eləcə də sosial rifah təminatının təşkili və ekoloji balansın qorunması ilə tənzimlənir.

Layihələrin idarə edilməsi isə iqtisadi tərəqqi strategiyalarının reallaşdırılmasının əsasıdır. Mövcud iqtisadi siyasətdə layihələrin idarə edilməsi strateji planlaşdırma əsasında operativ idarəetməni vəhdətdə ifadə edir. Əsasən inkişaf etməkdə olan ölkələrdə layihələrin idarə edilməsində iqtisadi modernləşmənin mühüm hesab edir.

Maliyyə resurslarının səfərbər edilməsinin iqtisadi əsasları. Əsasən makroiqtisadi sabitlikdə bərpa olunan enerji təminatı əsasında innovasiya yönümlü istehsalın formalaşmasını şərtləndirir. Belə meyarlar isə enerji idxalından asılılığı tarazlayır, tədiyə balansını sabitləşdirir, valyuta risklərini tənzimləyir (İsmayılov, 2021). Beləliklə, bərpa olunan enerji layihələri yeni iş yerlərini, davamlı iqtisadi artım əsasında innovasiyanı stimullaşdırır, istehsalın artımını həvəsləndirir.

Enerji təhlükəsizliyi qlobal geosiyasi risklər fonunda enerji mənbələrinin diversifikasiyası iqtisadi təhlükəsizliyin əsas komponentlərini əks etdirir. Bu kontekstdə bərpa olunan enerji təminatı alternativ mənbələrin vəhdətini şərtləndirir. İnkişaf etmiş və inkişaf etməkdə olan ölkələrin müqayisəli təhlili (cədvəl 2) qeyd edilir.

Cədvəl 2
Bərpa olunan enerji investisiyalarının ölkələrlə müqayisəsi (2025)

Dövlətlər	**Mənfəət**
Azərbaycanda	51,9
Pakistan	39
ABŞ	19
Digər inkişaf etməkdə olan ölkələr	22

Mənbə: Müxtəlif mənbələr əsasında müəllif tərəfindən tərtib edilmişdir.

Müqayisə üçün qeyd edək ki, inkişaf etmiş ölkələrin iqtisadiyyatında dövlət fiskal siyasətdə investisiya həcmini artırır. Misal üçün, ABŞ kimi sənaye iqtisadiyyatının miqyas effekti və innovasiya üstünlüyü digər ölkələrlə müqayisədə daha çoxdur. İnkişaf etməkdə olan ölkələrdə isə əsas problem maliyyə resurslarının məhdudluğudur. Qlobal investisiya meyarları və kapital siyasəti. Beynəlxalq maliyyə institutları və özəl şirkətlər tərəfindən bərpa olunan enerji layihələrinə yönəldilən maliyyə vəsaiti əhəmiyyətli hesab edilir. Belə ki, inkişaf etmiş ölkələrdə iqlim yönümlü investisiyalar davamlı iqtisadi artımı təmin edir və fiskal riskləri tənzimləyir. Beynəlxalq təcrübədə effektivlik və fiskal siyasət əsas prinsipi xarici iqtisadi fəaliyyətdə sosial artıma yönəldilir.

Cədvəl 3
2025-ci ildə Azərbaycanın dünya ölkələrilə xarici ticarəti (min. $)

№	Ölkələr	İxrac	İdxal	Dövriyyə
	Cəmi	**12.500.901,67**	**9.767.519,45**	**21.768.181,12**
	MDB ölkələrində, cəmi	**799.669,91**	**2.299.889,58**	**3.099.559,49**
	Dünya ölkələrində cəmi	**7.275.588,38**	**1.253.519,25**	**9.529.072,59**
1	ABŞ	164.482,73	272.002,15	436.494,78
2	Almaniya	318.991,36	383.871,81	702.863,17
3	Böyük Britaniya	164.306,25	126.515,23	290.821,49
4	Ukrayna	105.215,01	144.608,18	249.823,18
5	Pakistan	155,25	9.375,19	9.543,55
6	Nigeriya	65.815,591,	37,55	755,25
7	Yaponiya	9.399,94	162.257,55	171.657,49
8	Türkiyə	2.080.109,91	1.519.935,45	3.195.755,31
9	Rusiya	556.592,19	1.611.429,78	2.167.225,19
10	Xorvatiya	376.519, 55	3.922,97	379.583,19
11	Fransa	61.947,42	114.328,90	176.276,39
12	Misir	3.965,49	22.524,39	26.489,78
13	Tacikistan	5.519,55	529,77	2.937,19

Mənbə: DGK-in məlumatları əsasında müəllif tərəfindən hazırlanmışdır.

Belə şəraitdə dövlət maliyyə siyasəti vasitəsilə sosial məsrəfləri kompensasiya edir və maliyyə səmərəliliyində keyfiyyəti artırır. Bu kontekstdə maliyyə resurslarına laqeydlik və biganəlik sabitləşir, maliyyə səfərbərliyi nəticəsində sosial məsrəflər təmin edilir. Beləliklə, fiskal siyasət yalnız büdcə gəliri toplamaq məqsədi deyil, o, bazar tarazlığının sosial-iqtisadi rifahını tənzimləyir (Məmmədov, 2022a). Bərpa olunan enerji təminatında mövcud iqtisadi münasibətlər və yeni siyasi-iqtisadi, hüquq sistem davamlı sosial-iqtisadi tərəqqinin tənzimlənməsi əsasında sabitləşir.

Belə ki, ölkədə siyasi-iqtisadi fəaliyyət vətəndaş məmnunluğuna fokuslaşır. Maddi rifah artımı və sosial müdafiəsinin təminatı və daha mütərəqqi meyarları şərtləndirir. Beləliklə, dövlətin sosial-iqtisadi nailiyyəti əsasında cəmiyyətin hüquqlarının, qanuni maraqlarının ən ali təminatçısı və müdafiəçisidir. Dövlət həm də sabitliyə sosial-iqtisadi metodlarla təsir edir, ictimai tərəqqinin inkişafına şərait yaradır, iqtisadi münasibətlər sistemini təkmilləşdirir və bu münasibətləri tənzimləyir. Davud iqtisadi modelin istehsal meyarları kapital+siyasəti+innovasiya meyarları və hüquqi-siyasi amillərlə birlikdə şərh edir (Məmmədov, 2022a). Belə ki, qeyd edilən meyar istehsal funksiyaların artımı əsasında kapital və sərvətlə əlaqələndirir. Davud modeli istehsalı üç komponentdə strukturlaşdırır, tərəqqini şərtləndirən meyarlar, davamlı kapital artımı və hüquqi-siyasi iqtisadi qüvvə kimi sərvət əsasında. Təqdim edilən metod əsasında sosial-iqtisadi rifah formalaşır (Allahverdiyev, 2022). Dövlət iqtisadi siyasətində sosial rifah artımı, mülkiyyət hüquqlarının müəyyənləşməsində effektiv metoda üç əsas yanaşma mövcuddur. Maliyyə siyasətində fiskal model, sosial-rifah modeli, siyasi-iqtisadi model qeyd edilən prinsipləri əhatə edir. Belə maliyyə siyasətinin məqsəd dövlətin sahibkarlıq siyasəti və sosial sabitlik kontekstində elmi təhlili məqsədə uyğun hesab edir.

Dövlətin maliyyə siyasəti və bu istiqamətdə planlaşdırdığı iqtisadi tədbirlərin əsas məzmunu və məqsədi müxtəlif metodlar əsasında sosial rifah artımını təmin etməkdir. Beləliklə, inkişaf etmiş

ölkələrdə siyasi-iqtisadi bərabərlik iqtisadi sabitliyi şərtləndirir. Belə iqtisadi siyasət müəyyən prinsiplər əsasında, dövlət müəssisələrində və biznes mühitində sosial-iqtisadi münasibətlər sabitlik əsasında tənzimlənir. Mövcud şəraitdə dünyanın iqtisadi tərəqqisində ziddiyyətli məqamlar sosial-iqtisadi rifaha və siyasi sabitliyə problem kimi xarakterizə edilir ki, belə məsələlərin tənzimlənməsi isə xüsusi mülkiyyət əsasında mümkün olmur (Qənbərov, 2012). Belə problemlər isə dövlət tərəfindən siyasi-iqtisadi sabitliyin tənzimlənməsi əsasında formalaşır. Maliyyə tənzimləmə vasitələrinin qarşılıqlı nisbətini müəyyənləşdirən dövlətin normayaradıcı çoxnövlü fəaliyyəti, yəni sosial-iqtisadi və siyasi şəraitdə vətəndaş məmunluğu, insanların maddi rifah təminatının təşkilini şərtləndirir.

Davamlı iqtisadi artım nəticələri təhlilə əsasən bərpa olunan enerji siyasətinin nəticələri iqtisadi artımda keyfiyyətin təşkilini, ərzaq təminatının artımını, bu istiqamətdə maliyyə resurslarının səfərbər edilməsini şərtləndirir. Dünya ölkələrində müqayisəli iqtisadi siyasəti əsasən Asiya ölkələri, mühüm enerji mənbələri kimi dünya iqtisadiyyatında qlobal mövqeini qoruyur. Qlobal enerji investisiyalarının müəyyən hissəsi bu dövlətlərdən idxal edilir və burada idxal-ixrac, xarici yönələn investisiyanı gücləndirir (Nuriyev, 2021). Bu, Asiyanın sənaye və innovasiya üstünlüyünü, həmçinin iqtisadi effektini qeyd etməyə əsasdır. Şimali Amerikası stabil meyarı enerji investisiyalarında sabitdir, lakin artım tempi Asiyaya nisbətən aşağıdır. Bu, əsasən enerji bazarı və belə siyasətin daha əvvəl formalaşması ilə şərh edilir. İnkişaf etməkdə olan dövlətlərdə isə Latın Amerika əsasən Afrika dövlətlərinin gəlirləri hələ də minimaldır. Bu, investisiya şərtlərinin qeyri-sabitliyi, maliyyə sabitliyində qeyri-müəyyənliklər və sosial-iqtisadi siyasətdə problemlərlə əlaqədardır. Afrika kimi ölkələrdə enerji potensialı yüksək olmasına baxmayaraq investisiya siyasəti yetərli deyildir (Allahverdiyev, 2008). Beləliklə, ümumi iqtisadi şərait əsasən qlobal investisiyalar artımı ölkələrə nisbətən fərqlidir. Bu əsasən enerji gəlirlərinin artdığı halda, investisiyada isə hələ də həmin ölkələrdə qeyri-bərabərdir (İmanov, 2023). Amma Amerikada investisiya mühiti sabitdir, enerji siyasətində strateji layihələri mövcuddur.

Cədvəl 4
Qlobal investisiya nisbəti (2025 proqnoz, %)

Dövlətlər	Qlobal (%)	Status
Azərbaycan	**51,9**	İnkişaf etməkdə olan
Asiya ölkələri	49	İnkişaf edən sənaye dövlətləri
Amerika	13	İnkişaf etmiş
Digər Asiya	9	İnkişaf etməkdə olan

Mənbə: Müəllif tərəfindən statistik məlumatlar əsasında hazırlanmışdır.

Azərbaycan isə əsaslı enerji ixracatçısı olsa da, enerji sahəsində intensiv siyasət həyata keçirir. Bu, enerji ixrac modelinin əsas meyarları, davamlı fiskal sabitliyin gücləndirilməsinə xidmət edir. Azərbaycanda iqtisadi siyasətdə strateji mövqe əsasən külək enerjisi potensialını intensivləşdirmək və gələcəkdə investisiya layihələrinin artması planlaşdırılır.

Beləliklə, iqtisadi təsirin təhlili enerji sahəsinə yönələn kapitalın intensivliyi iqtisadi effektivliyi və ÜDM artımına təsir investisiya səmərəliliyi formalaşdırır (Məmmədov, 2022b). Tədiyə balansının tənzimlənməsi, enerji idxalının tarazlığı və xarici ticarətdə balansı sabitləşdirir.

Təhlil əsasən, Maliyyə resurslarının səfərbər edilməsi enerji təminatının əsas şərtidir. Davamlı iqtisadi sabitlik üçün enerji siyasəti strateji prioritet hesab edilir. Dövlət və özəl sahənin sosial-iqtisadi artımda əhəmiyyəti effektiv sosial rifaha əsaslanır (Marşal, 1993). Bu kontekstdə enerji təhlükəsizliyi, xarici asılılığı minimallaşdır və makroiqtisadi sabitliyi, davamlı sosial-iqtisadi artımda maliyyə effektivliyini tənzimləyir.

Maliyyə səmərəliliyi xarici effektlərin mikroiqtisadi problem kimi deyil, makroiqtisadi meyarlar kimi təhlili səciyəvidir. Bu, sosial rifah funksiyasında dövlət siyasətinin əsas meyarlarını qəbul edir. Beləliklə, Xarici iqtisadi fəaliyyətin sosial-iqtisadi rifaha təsiri dövlətin siyasi-iqtisadi səmərəliliyini təmin edir və fiskal alətlərin birgə tətbiqini zəruri edir. Belə müqayisə sosial rifah artımını şərtləndirir (Allahverdiyev, 2025). Xarici iqtisadi fəaliyyət effektivdirsə həmin ölkə sosial balansı tənzimləyir.

Davud hesab edir ki, xarici sərmayənin effektivi və resurslardan səmərəli istifadə müəyyən olduqda mülki iqtisadi siyasətin tərəqqi istiqaməti təşkil edilir. Beləliklə, siyasi-iqtisadi tərəqqidə davamlı sosial rifah intensivləşir və resursların iqtisadi dəyəri artır, xarici fəaliyyətin effektivliyi balanslaşır. Bu kontekstdə, mülkiyyət hüquqları siyasi-iqtisadi bərabərliyi təmin edilir və sosial məsrəflər daxili vəsait əsasında tənzimləyir. Bu meyarlar dövlətin bilavasitə fiskal müdaxiləsindən daha çox iqtisadi siyasətlə formalaşdırılmasına üstünlük verir.

Maliyyə resurslarının səfərbər edilməsinin iqtisadi əsasları. Maliyyə resurslarının səfərbər edilməsi iqtisadi sistemdə dövlətin və bazarın qarşılıqlı fəaliyyət meyarlarının əsas elementlərindən biridir. Bu proses fiskal gəlirlərin toplanması və milli iqtisadi təhlükəsizliyin, sosial sabitliyin və davamlı artımın təminatını şərtləndirir. İqtisadi elm maliyyə resurslarının səfərbər edilməsi üç əsas istiqamətdə, sosial rifah artımı və xarici iqtisadi fəaliyyət effekti, dövlətin iqtisadi tənzimləyici metoduna əsaslanır (Vəliyev, 2014).

Maliyyə səfərbərliyi sosial rifah funksiyası ilə əlaqəlidir. Bu kontekstdə dövlət məsrəfi əsasında sosial sabitlik təmin edilir və büdcə vəsaiti ilə iqtisadi balansın qorunmasına xidmət edir (Hacıyev, 2026). Fikrimizcə maliyyə səfərbərliyi siyasi-iqtisadi, sosial funksiyaları əhatə edir. Belə siyasi-iqtisadi fəaliyyət maliyyə resurslarının səfərbər edilməsində bazar iştirakçılarının hüquqi təminatı ilə əlaqəlidir.

Maliyyə resurslarının səfərbər edilməsinin iqtisadi funksiyaları. İnvestisiya təminatı, dövlət və özəl sahənin sosial rifaha formalaşdırır. Makroiqtisadi sabitlik, inflyasiya və büdcə balansının qorunmasını əhatə edir. İqtisadi təhlükəsizlik, davamlı iqtisadi rifahın maliyyə təminatını zəruri edir. Beləliklə, maliyyə resurslarının səfərbər edilməsi büdcə və qeyri-büdcəni əhatə edən iqtisadi siyasət, sabitliyi təmin edən sosial rifahdır.

Nəticə

Maliyyə resurslarının səfərbər edilməsi iqtisadi tərəqqinin sosial balansı və hüquqi sabitliyin qarşılıqlı təsiri nəticəsində formalaşan prosesdir. Effektiv fiskal siyasət sosial zərurəti müəyyən edir və mülkiyyət hüquqlarının təminatını şərtləndirir. İnkişaf etməkdə olan ölkələrdə davamlı sosial-iqtisadi rifah artımı əsasən xarici kapital və beynəlxalq maliyyə institutları vasitəsilə təmin olunur. Azərbaycan enerji iqtisadiyyatı, ənənəvi ixrac modelini qoruyur, eləcə də enerji iqtisadiyyatını kapital yönəldir. Maliyyə resurslarının səfərbər edilməsi enerji siyasətini intensivləşdirir və kapitalın daha məhsuldar istiqamətlərə yönəldilməsini təmin edir. Beləliklə, enerji siyasəti inkişafı qlobal iqtisadiyyatın davamlı artım modelini əks etdirir. Qlobal iqtisadi sistemdə enerji siyasətinin tərəqqisi ekoloji və kapitalın artımı ilə xarakterikdir. Enerji və ərzaq təhlükəsizliyi iqtisadi siyasətdə sabitliyi təmin edən sosial müdafiənin əsası kimi səciyələnir. Maliyyə resurslarının artırılması sosial-iqtisadi zərurətdir və bu proses qlobal maliyyə sistemində yeni siyasi-iqtisadi reallıqların formalaşmasına səbəb olur.

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Sosial maska fenomeni Azərbaycan televiziyası və sosial mediasında: tipologiya və arxetipik əsaslar (1995–2025)

Elçin Əlibəyli

Xülasə. *Məqalə Azərbaycan televiziya və sosial media məkanında 1995–2025-ci illər ərzində televiziya aparıcısının ekran obrazının, «sosial maska» fenomeninin tarixi transformasiyasını araşdırır. Tədqiqatda K. Q. Yunqun arxetip nəzəriyyəsi, M. Mark və K. Pirsonun brend arxetipləri sistemi, P. Bourdieu-nun mediya sosiologiyası, E. Tofflerin mədəni dinamika konsepsiyası metodoloji çərçivə kimi istifadə edilmişdir. Azərbaycan teleməkanının müstəqillik dövrü (1995–2005), infoteynment dövrü (2005–2015) və rəqəmsal media dominantlığı dövrü (2015–2025) kimi üç əsas mərhələ müəyyənləşdirilmiş, hər mərhələnin özünəxas arxetipik dominantları analiz edilmişdir. Tədqiqat göstərir ki, Azərbaycanda hər siyasi-iqtisadi dönüşüm öz dominant arxetipini televiziya ekranında materiallaşdırmış, rəqəmsal dövrdə isə bu arxetipik çevrilmə sosial mediada daha sürətlə baş vermişdir. 2025-ci ildə ənənəvi televiziyanın media istehlakındakı payı cəmi 17 faizə enmiş, Instagram/TikTok/qısa video platformaları isə 34 faizə çatmışdır. Müdrik arxetipinin sistemli marjinallaşması, Aşiq və Təlxək arxetiplərinin istehlak mədəniyyəti çərçivəsindəki üstünlüyü Azərbaycan ictimai sahəsi üçün simptomatik xəbərdarlıq kimi qiymətləndirilir.*

Açar sözlər: *sosial maska, televiziya aparıcısı, arxetip, ekran obrazı, Azərbaycan televiziyası, sosial media, rəqəmsal transformasiya, klip təfəkkürü, kütləvi kommunikasiya, infoteynment*

"Baku TV" MMC, sənətşünaslıq üzrə fəlsəfə doktoru, Bakı, Azərbaycan
E-poçt: elchinalibeyli@gmail.com
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The Social Mask Phenomenon in Azerbaijani Television and Social Media: Typology and Archetypal Foundations (1995–2025)

Elchin Alibeyli

Abstract. *This article examines the historical transformation of the television presenter's screen image and the «social mask» phenomenon in the Azerbaijani television and social media space from 1995 to 2025. The study employs C. G. Jung's archetype theory, M. Mark and C.Pearson's brand archetype system, P. Bourdieu's media sociology, and E. Toffler's cultural dynamics framework as methodological foundations. Three main periods are identified: the independence era (1995–2005), the infotainment era (2005–2015), and the digital media dominance era (2015–2025), with the characteristic archetypal dominants of each period analyzed. The research demonstrates that each political-economic transition in Azerbaijan materialized its own dominant archetype on the television screen, while in the digital era this archetypal transformation accelerated significantly on social media. By 2025, traditional television's share of media consumption had fallen to only 17%, while*

Instagram/TikTok/short-video platforms reached 34%. The systematic marginalization of the Sage archetype and the predominance of Lover and Jester archetypes within the consumer culture framework are evaluated as symptomatic warnings for the quality of Azerbaijan's public sphere.

Keywords: *social mask, television presenter, archetype, screen image, Azerbaijani television, social media, digital transformation, clip thinking, mass communication, infotainment*

"Baku TV" LLC, PhD in Art History, Baku, Azerbaijan
E-mail: elchinalibeyli@gmail.com
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Giriş

Müasir media mühitində televiziya aparıcısının fiquru artıq yalnız hazır informasiyanı ötürən şəxs kimi deyil, kontentin yaradılmasında fəal iştirak edən subyekt kimi müəyyən olunur. Televiziya aparıcısının obrazının formalaşması auditoriyanın etimad səviyyəsini müəyyən edən spesifik sosial maskanın qurulması ilə sıx bağlıdır. Müasir yayım praktikasında elə aparıcı tipləri mövcuddur ki, onların ictimai identikliyi müəyyən şəxsi keyfiyyətlərin – məsələn, sosial ədalətsizliyə qarşı kompromissiz mövqenin – nümayişi üzərində qurulur. Bu yanaşma tamaşaçı ilə aparıcı arasında xüsusi psixoloji yaxınlıq yaradır ki, bu fenomen klassik olaraq parasosial qarşılıqlı əlaqə kimi izah olunur (Liebers və Schramm, 2019, s. 217). Belə strategiya mediapersonaya emosional ifratlıq üzərində qurulmuş proqramlarla rəqabətdə üstünlük qazanmağa və auditoriyanın etibar reytinqlərində lider mövqe tutmağa imkan verir.

Televiziya dramaturgiyası kontekstində aparıcı eyni zamanda həm müəllif, həm də ifaçı funksiyasını yerinə yetirir. Onun davranışı verilişin süjet xəttinin inkişafını müəyyən edir. Struktur baxımdan aydın qurulmuş proqram aparıcının, moderatorun və ya şoumenin mövqeyini dəqiq şəkildə müəyyən etməyə imkan verir. Tədqiqatlar göstərir ki, dramaturji model olmadan televiziya məhsulunun keyfiyyətli təhlili mümkün deyil və bu, müasir media sistemində strukturun hələ də əsas rol oynadığını təsdiqləyir (Fuchs, 2021, s. 226).

Sosial maskanın yalnız aparıcının fərdi xüsusiyyətləri ilə izah olunması kifayət etmir. O, eyni zamanda formatın daxili məntiqi, kanalın brend strategiyası və dövrün sosial-psixoloji iqlimi ilə şərtlənən kompleks konstruksiyadır. Bu baxımdan aparıcı obrazı təkcə şəxsi identiklik deyil, institusional və mədəni kontekstin məhsulu kimi çıxış edir. Xəbər proqramının aparıcısı mədəniyyətin "nüvə dəyərlərini" — etibarlılıq, sabitlik və səlahiyyətlilik kimi keyfiyyətləri təmsil etməlidir. Əyləncə proqramında isə aparıcı fərqli funksional yük daşıyır: o, emosional enerji, dinamika və pozitiv atmosfer yaradan fiqura çevrilir. Tok-şou aparıcısı isə üçüncü model kimi çıxış edir — o, sosial reallığın güzgüsüdür və müxtəlif ictimai təbəqələrin baxışlarını mediativ formada təqdim edir. Bu fərqlər göstərir ki, sosial maska abstrakt kateqoriya deyil, formatın funksional tələbləri ilə konkret şəkildə müəyyən olunur.

Aparıcı ekranda nə qədər çox təkrarlanırsa, onun obrazı bir o qədər sabitləşir və tamaşaçının şüurunda "donmuş" forma alır. Bu sabitlik bir tərəfdən tanınma və etibar yaradır, digər tərəfdən isə obrazın çoxqatlılığını və daxili mürəkkəbliyini kölgədə qoyur.

Bu tədqiqat çərçivəsində sosial maska belə tərif olunur: sosial maska — müəyyən ictimai fikri, dünyagörüşünü və sosial-psixoloji münasibəti ifadə etmək iddiasında olan televiziya aparıcısının ümumiləşdirilmiş tipidir; aparıcı öz davranışı və kommunikasiya strategiyası vasitəsilə müəyyən

auditoriya qrupunun ictimai rəyini və psixoloji durumunu təmsil edir. Bu yanaşma əvvəlki tədqiqatda irəli sürdüyümüz müddəa ilə üst-üstə düşür (Əlibəyli, 2011, s. 38).

Fransız sosioloqu Pierre Bourdieu televiziya görünürlüyünün sosial status üzərində təsirini kəskin şəkildə ifadə edirdi: "olmaq — televiziyada göstərilmək deməkdir" (Hesmondhalgh, 2015, s. 78). Bu fikir Azərbaycan kontekstində xüsusi aktuallıq qazanır. Burada ictimai kommunikasiya kanallarının məhdudluğu və şəxsi şəbəkələrə əsaslanan sosial münasibətlər sistemi televiziya görünürlüyünü sosial kapitalın əsas formalarından birinə çevirir. Rəqəmsal dövrdə isə bu proses daha da genişlənmişdir: artıq "görünmək" yalnız televiziya ilə məhdudlaşmır, sosial media platformaları da bu funksiyanı öz üzərinə götürür (van Dijck və b., 2018, s. 216).

Karl Qustav Yunqun kollektiv şüursuzluq nəzəriyyəsi aparıcı obrazının dərin psixoloji qatlarını izah etmək üçün mühüm metodoloji baza yaradır. Yunqa görə, insan psixikasında fərdi şüursuzluqla yanaşı, bəşəriyyətin ortaq təcrübəsini daşıyan kollektiv şüursuzluq da mövcuddur və burada arxetiplər fəaliyyət göstərir. Bu arxetiplər universal obrazlar kimi müxtəlif mədəniyyətlərdə təkrar olunur (Stevens, 2018, s. 330). Televiziya aparıcısının sosial maskası — şüurlu şəkildə qurulsa da, ya da spontan formalaşsa da — bu arxetiplərlə rezonansa girir. Tamaşaçı aparıcını "tanış tip" kimi qəbul edir, çünki həmin obraz artıq onun kollektiv şüursuzluğunda mövcuddur.

Mark və Pearson tərəfindən işlənmiş 12 arxetip modeli bu yanaşmanı praktik müstəviyə keçirir. Onların təsnifatı göstərir ki, hər arxetip müəyyən kommunikasiya üslubu, emosional ton və auditoriya gözləntiləri ilə bağlıdır (Pera və b., 2016, s. 48). Bu sistem televiziya aparıcılarının funksional tiplərini daha dəqiq analiz etməyə imkan verir. Lakin arxetiplərin konkret ifadəsi milli-mədəni kontekstdən asılıdır. Məsələn, Qərb mediasında "Qəhrəman" arxetipi fərdi nailiyyət üzərində qurulursa, Azərbaycan kontekstində bu obraz daha çox kollektiv yaddaş, tarixi təcrübə və milli dirəniş ideyaları ilə bağlıdır.

Elvin Tofflerin "Üçüncü dalğa" nəzəriyyəsi auditoriya transformasiyasını anlamaq üçün mühüm çərçivə təqdim edir. Tofflerə görə, sənaye cəmiyyətinin tamaşaçısı bütöv və sabit narrativlərə ehtiyac duyur, lakin informasiya cəmiyyətində formalaşan yeni tamaşaçı fraqmentli informasiya axınını daha rahat qəbul edir (Toffler, 2020, s. 308). Azərbaycan mediasında da bu keçid müşahidə olunur: 1990-cı illərin auditoriyası vahid ideoloji çərçivələr axtarırdısa, müasir gənc auditoriya sosial media fraqmentlərini sərbəst şəkildə mənimsəyir.

Abraham Molun "mozaik mədəniyyət" konsepsiyası bu transformasiyanın mədəni məntiqini izah edir. Müasir informasiya mühitində biliklər artıq iyerarxik sistem şəklində deyil, fraqmentar və assosiativ şəkildə təşkil olunur (Moles, 2019, s. 89). Bu proses Azərbaycan televiziya məkanında da öz əksini tapır. Elçin Əlibəylinin qeyd etdiyi kimi, klip montajı artıq yalnız texniki üsul deyil, estetik prinsipə çevrilmişdir: "görüntüyə hiss və emosiya gətirir, gerçəklik arxa plana keçir və əyləncəli, stimullaşdırıcı simulyativ dünya formalaşır" (Əlibəyli, 2016, s. 118).

Beləliklə, sosial maska anlayışı yalnız fərdi psixologiya ilə deyil, teatr estetikasından başlayaraq sosiologiya, psixologiya və media nəzəriyyəsinə qədər uzanan çoxqatlı nəzəri çərçivədə izah olunur. Bu yanaşma televiziya aparıcısını sadəcə informasiya ötürücüsü kimi deyil, mədəni kodları, sosial gözləntiləri və kollektiv təsəvvürləri daşıyan kompleks mediativ fiqur kimi dərk etməyə imkan verir.

Metodolar

Televiziya məkanında sosial maskanın psixoloji təbiəti funksional kompleks kimi müəyyən olunur. Bu kompleks fərd tərəfindən xarici mühitə uyğunlaşmaq və ya müəyyən kommunikativ üstünlüklər əldə etmək məqsədilə formalaşdırılır. Bu struktur insanın autentik şəxsiyyəti ilə eyniləşdirilə bilməz.

Əksinə, o, subyektin mənsub olduğu sosial mühitin gözləntilərinə cavab vermək üçün ifa etdiyi sosial roldur.

Bu baxımdan aparıcının davranışı və özünü təqdimetmə strategiyası onun daxili identikliyinin birbaşa ifadəsi deyil, daha çox sosial normativlərə uyğunlaşdırılmış performativ model kimi çıxış edir. Sosial maska fəaliyyət göstərdiyi müddətdə fərdin həqiqi xüsusiyyətlərini qismən gizlədir və onları ictimaiyyət tərəfindən gözlənilən keyfiyyətlər sistemi ilə əvəz edir (Goffman, 2022, s. 187). Bu proses mediada xüsusilə nəzərə çarpır, çünki televiziya aparıcısı daim ictimai baxış altındadır və onun obrazı sabit, tanınan və proqnozlaşdırıla bilən olmalıdır.

Tədqiqatçılar qeyd edirlər ki, sosial maska zaman keçdikcə "canlı üzün" spontanlığını zəiflədir və onu sabit sxemə çevirir. Bu transformasiya nəticəsində aparıcının obrazı dinamik və dəyişkən fərdi xüsusiyyətlərdən uzaqlaşaraq daha çox stereotipləşmiş və əvvəlcədən müəyyən olunmuş model kimi qəbul edilir. Beləliklə, sosial maska bir tərəfdən kommunikativ effektivliyi və auditoriya ilə sabit əlaqəni təmin edir, digər tərəfdən isə fərdi autentikliyin görünmə imkanlarını məhdudlaşdırır.

Aşağıdakı cədvəl tədqiqatın üç əsas dövründə Azərbaycan televiziyasının dominant arxetiplərini, əsas kanal nümunələrini, aparıcı tiplərini və auditoriya identifikasiya modelini sistemli şəkildə təqdim edir. Televiziya efirində aparıcının mütəmadi görünməsi onun şəxsiyyətinin auditoriya tərəfindən qavranılmasına qaçılmaz şəkildə təsir göstərir. Zaman keçdikcə fərdi xüsusiyyətlər arxa plana keçir, onların yerini isə sabitləşmiş sosial maska tutur. Bu maska tədricən müəyyən ideyaların daşıyıcısına, daha dəqiq desək, tipik mediativ obrazına çevrilir. Müasir media praktikasında mediapersonanın real xüsusiyyətləri çox vaxt ikinci plana sıxışdırılır, ön plana isə formalaşdırılmış obraz çıxır və tamaşaçı onu konkret proqramın tematikası ilə möhkəm şəkildə assosiasiya edir.

Birinci dövrdə (1995–2005) auditoriya–aparıcı münasibətləri "etimad → itaət" modeli üzərində qurulmuşdur. Tamaşaçı aparıcıya inanır, onun təqdim etdiyi informasiyanı sorğulamadan qəbul edir və ona ictimai nüfuz sahibi kimi yanaşır. Bu modelin kökü sovet dövrünün "ictimai nüfuz" anlayışına gedib çıxır. Dövlət televiziyasının diktoruna etibar onun institusional legitimliyindən qaynaqlanırdı, ANS kimi alternativ platformalarda isə etibar senzurasız danışıqla əsaslandırılırdı. Hər iki halda aparıcı arxetipik "sima" funksiyasını yerinə yetirərək müəyyən dəyərləri və dünyagörüşünü təcəssüm etdirirdi. Bu mərhələdə tamaşaçı passiv qəbuledici idi və sosial maskanı qəbul etsə də, onunla fəal qarşılıqlı münasibətə girmirdi. Bu kontekst Pierre Bourdieu-nun "göstərilmək — olmaqdır" tezisinin ən güclü şəkildə işlədiyi mərhələ kimi xarakterizə oluna bilər (Hesmondhalgh, 2015, s. 58).

İkinci dövrdə (2005–2015) auditoriya–aparıcı münasibətləri "seçim → müqayisə" modeli üzərində inkişaf edir. Çoxkanallı mühitin formalaşması ilə tamaşaçı artıq aktiv seçim subyektinə çevrilir. Hansı aparıcını izləmək, hansı formatı üstün tutmaq kimi qərarlar onun sosial identikliyinin ifadəsinə çevrilir. Bu mərhələdə tamaşaçı yalnız kontenti qəbul etmir, eyni zamanda onu müqayisə edir və qiymətləndirir. Beləliklə, "görünmək" yalnız aparıcı üçün deyil, tamaşaçının öz seçimlərini nümayiş etdirməsi baxımından da sosial siqnala çevrilir.

Üçüncü dövrdə (2015–2025) rəqəmsal mühit auditoriya–aparıcı münasibətlərini köklü şəkildə transformasiya edir. İzləyici artıq yalnız istehlakçı deyil, həm də kontent yaradıcısıdır: o şərh yazır, paylaşır, tənqid edir, parodiya yaradır və alternativ platformalarda cavab verir. Bu aktiv iştirak modeli sosial maskanın funksiyasını dəyişdirir. Artıq maska sadəcə təqdim olunmur, o, ictimai müzakirəyə çıxarılır, test edilir və kollektiv şəkildə qiymətləndirilir. Belə şəraitdə "inanılan maska" daha sürətlə dekonstruksiya olunur, çünki çoxsaylı auditoriya onu daim yoxlayır və sorğulayır.

Televiziya gerçəkliyinin konstruksiya mexanizmi iyerarxik xarakter daşıyır: kanalın ideoloji və iqtisadi çərçivəsi → formatın dramaturji tələbləri → rejissor və prodüserin seçimləri → aparıcının sosial maskası → tamaşaçının identifikasiya və ya rədd reaksiyası. Bu zəncirdə hər bir mərhələ

növbəti mərhələnin sərhədlərini müəyyən edir. Aparıcı bu sistemin görünən insan simasıdır, lakin onun arxasında mürəkkəb institusional və estetik mexanizm dayanır. Bu mexanizm yalnız öz məntiqinə uyğun arxetipik modellərin formalaşmasına imkan verir: dövlət televiziyası daha çox "Hakim" arxetipini təşviq edir, kommersiya kanalları isə "Təlxək" və "Aşiq" arxetiplərinə meyillənir.

Rəqəmsal mühit isə fərqli konstruksiya prinsipinə əsaslanır: platforma alqoritmi → kontent yaradıcısı → auditoriya reaksiyası → yenidən alqoritmik yayım. Burada əsas rol insan faktorundan çox alqoritmə məxsusdur. Alqoritm isə tamaşaçı davranışından öyrənir və emosional reaksiya doğuran kontenti daha geniş yayır. Bu, xüsusilə "Təlxək" və "Aşiq" arxetiplərinin güclənməsinə səbəb olur, çünki emosional və sensasion məzmun daha çox qarşılıqlı əlaqə yaradır.

"Müdrik" arxetipinin Azərbaycan media məkanında transformasiyası bu kontekstdə diqqətəlayiqdir. Birinci dövrdə bu arxetip mövcud olsa da, zəif təmsil olunurdu. İkinci dövrdə infoteynment məntiqinin güclənməsi ilə o, marjinallaşdı. Üçüncü dövrdə isə televiziya məkanından çəkilərək rəqəmsal platformalara — YouTube, podkastlar və Telegram kanallarına keçdi. Bu transformasiya ictimai diskursun keyfiyyətinə birbaşa təsir göstərir.

Jürgen Habermasın "ictimai sahə" konsepsiyasına görə, demokratik cəmiyyətin keyfiyyəti rasional müzakirə mühitinin səviyyəsi ilə ölçülür (Habermas, 2021). Müdrik arxetipi bu mühitin əsas daşıyıcısıdır. Onun marjinallaşması ictimai diskursun emosional, fraqmentar və səthi xarakter almasına gətirib çıxarır. Bu tendensiya Azərbaycan kontekstində də müşahidə olunur və analitik düşüncə səviyyəsinin azalması ilə müşayiət edilir (Əlibəyli, 2016, s. 178).

Beləliklə, televiziya aparıcısının sosial maskası yalnız fərdi xüsusiyyətlərin deyil, tarixi mərhələlərin, media texnologiyalarının və sosial münasibətlərin qarşılıqlı təsiri nəticəsində formalaşan dinamik konstruksiyadır. Onun transformasiyası isə birbaşa olaraq cəmiyyətin kommunikativ strukturlarının dəyişməsi ilə bağlıdır.

Cədvəl 1
Azərbaycan televiziyasında arxetipik dominantlar (1995–2025)

Dövr	Dominant arxetiplər	Əsas kanallar	Aparıcı tipi	Auditoriya modeli
1995–2005	Qəhrəman + Hakim	ANS, AzTV	Diktor-Qəhrəman, Hakim-Diktor	İkinci dalğa (bütöv narrativ axtarışı)
2005–2015	Təlxək + Aşiq (dominant); Hakim (azalır); Müdrik (marjinal)	Lider, Space, İctimai TV	Şoumen, Müğənni-aparıcı, İnfoteynment xəbərçisi	Keçid (İkinci → Üçüncü dalğa)
2015–2025	Aşiq + Təlxək (TV); Yaxşı adam + Qəhrəman (SM); Müdrik (Telegram)	CBC, İctimai TV + Instagram, TikTok, Telegram	İnfluencer, SMM aparıcısı, anonim analitik	Üçüncü dalğa + klip məntiqli nəsil

Mənbə: (Əlibəyli, 2025, s. 304).

Ənənəvi televiziyanın auditoriya payının azalması onun tam şəkildə marjinallaşması anlamına gəlmir. Sadəcə funksiyası dəyişmişdir: o, dominant platformadan çoxsaylı platformalar arasında birinə çevrilmişdir. Bu transformasiya xüsusilə 2010-cu illərin əvvəlindən etibarən sürətlənmişdir. Televiziya kanallarının sosial media hesablarının açılması və aparıcıların şəxsi platformalarda

aktivləşməsi nəticəsində sosial maska artıq iki paralel mühitdə mövcud olmağa başlamışdır — studiya daxilində və rəqəmsal platformalarda. Bu isə aparıcını fərqli kommunikativ tələblər və arxetipik seçimlər qarşısında qoyur.

2015-ci ildən sonra Azərbaycanda influencer fenomeninin formalaşması sosial maskanın yeni tipologiyasını ortaya çıxardı. Bu mühitdə üç əsas arxetipik model dominantlıq qazandı. Birincisi, Aşiq arxetipi — vizual estetika, şəxsi həyat hekayələri və emosional yaxınlıq üzərində qurulan model. İkincisi, Yaxşı adam arxetipi — gündəlik həyatın sadəliyini və "hamı kimi olmağı" ifadə edən model. Üçüncüsü isə Qəhrəman arxetipi — uğur hekayələri və fərdi mübarizə narrativləri üzərində qurulan model. Müdrik arxetipi isə sosial mediada daha az görünür, çünki dərin analitik kontent klip əsaslı sürətli informasiya axını ilə uyğunlaşmaqda çətinlik çəkir.

Televiziya mühitində sosial maska uzunmüddətli proses nəticəsində formalaşırdı. Aparıcı obrazı zamanla sabitləşir, auditoriya ilə etibarlı əlaqə qururdu. Sosial mediada isə bu proses kəskin şəkildə fərqlənir: bir kontent vahidi sürətlə viral ola, eyni sürətlə də unudula bilər. Bu səbəbdən influencer öz sosial maskasını daim yeniləməli, lakin onun arxetipik əsasını qoruyub saxlamalıdır. Bu paradoks — dəyişərək sabit qalmaq — müasir rəqəmsal mediapersonanın əsas peşəkar dilemmasıdır.

Azərbaycan influencer mühitinin spesifik xüsusiyyətləri də diqqətəlayiqdir. Ailə dəyərləri, milli kimlik, ənənəvi mədəni elementlər — mətbəx, geyim, məişət — sosial maskanın qurulmasında mühüm resurs kimi çıxış edir. Bu, Qayğıkeş və Sadəlövh arxetiplərinin lokal sintezini yaradır. Digər tərəfdən, sosial mobillik arzusu Qəhrəman arxetipinin güclənməsinə səbəb olur. Yerli yumor isə Təlxək arxetipinin mədəni adaptasiyası kimi çıxış edir və geniş auditoriya rezonansı yaradır.

TikTok platforması sosial maskanın formalaşma sürətini maksimum səviyyəyə çatdırmışdır. Burada aparıcı obrazı qısa müddətdə qurulur və eyni sürətlə dağıla bilər. Platformanın arxetipik strukturu əsasən Təlxək arxetipinə uyğun gəlir, lakin son illərdə "edutainment" modeli — yəni Təlxək və Müdrik arxetiplərinin hibridi — müəyyən inkişaf potensialı göstərir.

Telegram platforması isə fərqli arxetipik məntiqə malikdir. Burada vizual deyil, məzmun əsas resursdur və bu səbəbdən Hakim arxetipi üstünlük təşkil edir. Analitik yazılar, xəbər və şərh əsaslı kontent bu platformada etibarlılıq və nüfuz üzərində qurulan sosial maskaların formalaşmasına şərait yaradır. Anonimlik faktoru isə Üsyançı və Müdrik arxetiplərinin daha sərbəst ifadəsinə imkan verir. Bu baxımdan anonim Telegram kanallarını müəyyən mənada 1990-cı illərin alternativ media ruhunun rəqəmsal davamı kimi qiymətləndirmək mümkündür.

Rəqəmsal dövrün ən mürəkkəb fenomenlərindən biri televiziya aparıcısının paralel identikliklər qurmasıdır. Televiziyada onun sosial maskası kanalın brend strategiyası ilə müəyyən olunur, sosial mediada isə o, nisbətən müstəqil şəkildə özünü təqdim edir. Bu ikili struktur bəzən ziddiyyət yaratsa da, çox vaxt auditoriya tərəfindən fərqli kontekstlərdə qəbul edilir: televiziya aparıcısı "rəsmi", sosial mediada isə "daha real" kimi qavranılır. Bu "həqiqilik performansı" xüsusilə Aşiq arxetipinin effektivliyini artırır.

Son illərdə sosial media auditoriyasının televiziya auditoriyasını üstələməsi aparıcının statusunda fundamental dəyişiklik yaratmışdır. Artıq aparıcı yalnız kanalın resursu deyil, öz auditoriyasını özü ilə gətirən müstəqil mediabrenddir. Bu, sosial maskanın agentliyinin institusional çərçivədən çıxaraq fərdiləşməsi deməkdir.

Süni intellekt əsaslı kontent istehsalı isə sosial maska anlayışını yeni suallar qarşısında qoyur. Texniki baxımdan artıq insan olmadan da "maskanın" yaradılması mümkündür. Lakin arxetipik baxımdan bu proses hələ tam legitim görünmür. Arxetiplər kollektiv şüursuzluqla bağlıdır və onların aktivləşməsi üçün insan təcrübəsinin canlılığı, qeyri-mükəmməlliyi və risk elementi vacibdir. Virtual influencerlər

müəyyən arxetipləri — xüsusilə Aşiq modelini — simulyasiya edə bilsə də, Qəhrəman və ya Müdrik arxetiplərinin dərinliyini tam şəkildə əvəz edə bilmir.

Beləliklə, 2015–2025-ci illər Azərbaycan media məkanında sosial maskanın televiziya sərhədlərini aşaraq çoxplatformalı və dinamik fenomenə çevrildiyi dövr kimi xarakterizə olunur. Bu transformasiya bir tərəfdən arxetipik müxtəlifliyi artırmış, digər tərəfdən isə alqoritmik mexanizmlər vasitəsilə müəyyən arxetiplərin sistemli üstünlüyünü təmin etmişdir.

Cədvəl 2
Azərbaycan televiziya məkanında arxetipik paylanmanın şərti dinamikası (%)

Arxetip	1995–2005 (%)	2005–2015 (%)	2015–2025 TV (%)	2015–2025 SM (%)
Hakim	35	20	25	10
Qəhrəman	30	15	10	20
Təlxək	15	25	30	30
Aşiq	10	25	25	25
Müdrik	5	5	5	10
Digər (Yaxşı adam, Üsyançı, Qayğıkeş)	5	10	5	5

Mənbə: (Əlibəyli, 2025, s. 304).

Müasir Azərbaycan televiziya məkanının arxetipik xəritəsini geniş şəkildə təhlil etdikdə aydın olur ki, bu struktur yalnız estetik və janr seçimi ilə deyil, həm də sosial güc münasibətləri, iqtisadi maraqlar və auditoriya davranış modelləri ilə müəyyən olunur. Başqa sözlə, arxetiplər burada yalnız psixoloji kateqoriya deyil, institusional olaraq istehsal olunan və idarə olunan kommunikativ modellərdir.

Birinci istiqamət — kanallar üzrə arxetipik bölgü — konkret nümunələr əsasında daha aydın görünür. Məsələn, Azərbaycan dövlət televiziya sistemində, xüsusilə AzTV və İctimai Televiziya kimi platformalarda xəbər və ictimai-siyasi proqramların aparıcıları əsasən Hakim arxetipini təcəssüm etdirirlər. Bu aparıcıların nitqində intonasiya sabitdir, emosional amplituda məhduddur, təqdimat forması isə institusional etibarlılıq üzərində qurulur. Məsələn, xəbər buraxılışlarında aparıcının şəxsi münasibəti minimuma endirilir, onun sosial maskası "obyektiv dövlət səsi" kimi kodlaşdırılır. Bu model tamaşaçıda sabitlik və etibar hissi yaratsa da, alternativ baxışların ifadəsi üçün məhdud imkanlar təqdim edir.

Digər tərəfdən, ARB 24 və Baku TV kimi daha dinamik xəbər platformalarında Hakim arxetipi ilə yanaşı Qəhrəman və qismən Üsyançı arxetiplərinin elementləri də müşahidə olunur. Məsələn, canlı yayım formatında aparıcının hadisəyə operativ reaksiyası, bəzən emosional tonun artması, mübahisəli mövzulara daha sərt yanaşma bu arxetiplərin qarışığını yaradır. Xüsusilə müharibə və ya böhran dövrlərində aparıcı obrazı "situasiyanı idarə edən" və ya "həqiqəti açan" qəhrəman kimi təqdim olunur.

Əyləncə və infoteynment seqmentində isə arxetipik struktur tamamilə fərqlidir. ATV və Xəzər TV kimi kanallarda yayımlanan səhər proqramları və şou formatlarında Təlxək və Aşiq arxetiplərinin dominantlığı açıq şəkildə görünür. Aparıcı burada informasiya ötürücüsü deyil, emosional atmosfer

yaradan fiqurdur. Məsələn, "səhər şou" formatlarında aparıcının jestləri, mimikası, improvizasiya qabiliyyəti və şəxsi həyat elementlərinin paylaşılması tamaşaçı ilə yaxınlıq hissi yaradır. Bu isə parasosial münasibətin güclənməsinə səbəb olur (Liebers və Schramm, 2019, s. 217).

İkinci istiqamət — Müdrik arxetipinin marjinallaşması — daha dərin struktur problem kimi ortaya çıxır. Analitik və intellektual müzakirə tələb edən proqramlar Azərbaycan televiziya məkanında mövcud olsa da, onların auditoriya payı və təsir gücü məhduddur. Məsələn, uzunmüddətli diskussiya formatları ya gec saatlara yerləşdirilir, ya da daha geniş auditoriyaya çatmır. Bu vəziyyət təsadüfi deyil; reklam bazarının məntiqi və reytinq sistemi emosional və sürətli kontenti stimullaşdırır. Nəticədə Müdrik arxetipi sistem daxilində sıxışdırılır və ya periferiya mövqeyinə çəkilir.

Bu kontekstdə "eyni ekspertlər" fenomeni xüsusi diqqət tələb edir. Müasir televiziya debatlarında tez-tez eyni ekspertlərin təkrar-təkrar iştirak etməsi müşahidə olunur. Bu ekspertlər müxtəlif mövqeləri təmsil etsələr də, onların diskursu müəyyən çərçivədən kənara çıxmır. Beləliklə, dialoq formal olaraq mövcud olsa da, əslində əvvəlcədən müəyyən edilmiş ideoloji sərhədlər daxilində baş verir. Bu isə Habermasın təsvir etdiyi açıq ictimai müzakirə modelindən uzaqlaşmanı göstərir (Habermas, 2021, s. 289).

Üçüncü istiqamət — ictimai sahənin lokallaşması — bu proseslərin nəticəsi kimi ortaya çıxır. Televiziya kanalları öz auditoriya seqmentlərinə uyğun arxetipik çərçivələr qurur və həmin çərçivələr daxilində kommunikasiya aparır. Məsələn, bir kanal daha çox konservativ və sabitlik yönümlü auditoriyaya xitab edirsə, onun aparıcıları Hakim arxetipinə yaxın sosial maska formalaşdırır. Digər kanal isə daha gənc və emosional auditoriyanı hədəfləyirsə, Təlxək və Aşiq arxetiplərinə üstünlük verir. Nəticədə fərqli arxetipik "informasiya adaları" yaranır və bu adalar arasında real kommunikasiya zəifləyir.

Bu lokallaşma sosial mediada daha da dərinləşir. Televiziyada artıq mövcud olan arxetipik bölünmə rəqəmsal platformalarda alqoritmik filtrasiya ilə güclənir. Tamaşaçı yalnız öz maraq dairəsinə uyğun kontenti görür və alternativ baxışlarla qarşılaşma ehtimalı azalır (van Dijck və b., 2018, s. 161). Bu isə ictimai diskursun parçalanmasına gətirib çıxarır.

Nəticə

Nəticə etibarilə, müasir Azərbaycan televiziya məkanının arxetipik xəritəsi yalnız media strukturunu deyil, həm də cəmiyyətin kommunikativ modelini əks etdirir. Hakim, Təlxək və Aşiq arxetiplərinin dominantlığı, Müdrik arxetipinin isə marjinallaşması ictimai müzakirənin keyfiyyətinə birbaşa təsir göstərir. Bu tendensiya davam edərsə, uzunmüddətli perspektivdə rasional ictimai dialoqun zəifləməsi və emosional fragmentasiya riskinin artması qaçılmaz görünür.

Aparılan tədqiqat göstərir ki, Azərbaycan televiziya və sosial media məkanında "sosial maska" fenomeni statik deyil, tarixi mərhələlər, texnoloji transformasiyalar və sosial münasibətlər sisteminin qarşılıqlı təsiri nəticəsində formalaşan dinamik kommunikativ konstruksiyadır. 1995–2025-ci illəri əhatə edən analiz sübut edir ki, hər bir mərhələdə dominant arxetiplərin dəyişməsi yalnız estetik seçim deyil, eyni zamanda siyasi-iqtisadi konfiqurasiyanın və media institutlarının struktur məntiqinin nəticəsidir.

Birinci mərhələdə (1995–2005) televiziya aparıcısı "etimad və legitimlik" üzərində qurulan sosial maska ilə çıxış etmiş, Hakim və Qəhrəman arxetipləri ictimai şüurun təşkilində əsas rol oynamışdır. İkinci mərhələdə (2005–2015) infoteynment məntiqinin güclənməsi nəticəsində sosial maska daha çox emosional və performativ xarakter almış, Təlxək və Aşiq arxetipləri dominant mövqeyə yüksəlmişdir. Üçüncü mərhələdə (2015–2025) isə rəqəmsal platformaların təsiri ilə sosial maska çoxplatformalı, fragmentar və yüksək sürətli transformasiya edən modelə çevrilmişdir.

Tədqiqatın əsas elmi nəticələrindən biri odur ki, sosial maska yalnız aparıcının fərdi xüsusiyyətlərinin məhsulu deyil; o, kanalın brend strategiyası, formatın dramaturji strukturu və alqoritmik yayım mexanizmləri ilə şərtlənən institusional konstruksiyadır. Bu baxımdan televiziya və sosial media arasında fundamental fərq müəyyən edilir: televiziya sosial maskanı iyerarxik şəkildə formalaşdırırsa, rəqəmsal platformalar onu alqoritmik seleksiya və auditoriya reaksiyası vasitəsilə dinamik şəkildə yenidən qurur.

Digər mühüm nəticə "Müdrik" arxetipinin sistemli marjinallaşması ilə bağlıdır. Analiz göstərir ki, rasional və analitik diskursu daşıyan bu arxetip televiziya məkanında zəifləyərək periferiya mövqeyinə çəkilmiş, rəqəmsal mühitdə isə əsasən Telegram və alternativ platformalarda qismən bərpa olunmuşdur. Bu proses ictimai diskursun keyfiyyətinə birbaşa təsir göstərərək onun emosional, fragmentar və səthi xarakter almasına səbəb olmuşdur.

Eyni zamanda müəyyən edilmişdir ki, müasir Azərbaycan mediasında arxetipik bölgü kanallar üzrə sabit şəkildə strukturlaşır və bu bölgü auditoriyanın seqmentləşməsi ilə paralel inkişaf edir. Nəticədə "lokallaşmış ictimai sahə" formalaşır: müxtəlif arxetipik modellər üzərində qurulan kommunikativ "adalar" yaranır və bu adalar arasında real dialoq zəifləyir. Bu tendensiya sosial mediada alqoritmik filtrasiya vasitəsilə daha da güclənir.

Tədqiqat həmçinin göstərir ki, müasir dövrdə aparıcı artıq yalnız media institutunun nümayəndəsi deyil, paralel olaraq şəxsi mediabrend kimi çıxış edir. Bu isə sosial maskanın agentliyinin institusional çərçivədən fərdi səviyyəyə keçməsi deməkdir. Lakin bu proses yeni paradoks yaradır: aparıcı eyni zamanda həm sabit arxetipik identiklik saxlamalı, həm də platforma dinamikasına uyğun olaraq daim dəyişməlidir.

Beləliklə, sosial maska fenomeni müasir Azərbaycan media sistemində yalnız kommunikativ texnika deyil, ictimai şüurun formalaşmasına təsir edən strateji mexanizm kimi çıxış edir. Onun transformasiyası media texnologiyalarının inkişafı ilə yanaşı, ictimai sahənin strukturunun dəyişməsi, auditoriya davranışının transformasiyası və arxetipik modellərin yenidən paylanması ilə sıx bağlıdır.

Birinci nəticə. Hər siyasi-iqtisadi dönüşüm öz dominant arxetipini televiziya ekranında materiallaşdırır.
İkinci nəticə. «Sosial maska» heç vaxt yalnız fərdi seçim deyil — o, formatın, brendin, dövrün tələbi ilə şərtlənir.
Üçüncü nəticə. Arxetipik zənginlik demokratik dövrlərlə, arxetipik kasıblıq isə siyasi nəzarət dövrləri, kommersiya baskısı dövrləri ilə korrelyasiya göstərir.
Dördüncü tapıntı. Klip təfəkkürü dövründə sosial maskanın yaranma sürəti artmış, ömrü isə qısalmışdır.
Beşinci nəticə. Müdrik arxetipinin sistemli marjinallaşması Azərbaycan ictimai sahəsi üçün simptomatik xəbərdarlıqdır.

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A Linguostylistic Analysis of Trump's Spontaneous Foreign-Policy Remarks During the Merz Meeting: A Case Study

Hasan Alisoy[1*], Ilhama Mammadova[1], Yasin Babazade[1], Zarifa Sadigzade[1], Elnaz Aliyeva[1]

Abstract. *This article presents a case study examining the linguostylistic features of Donald Trump's spontaneous foreign-policy remarks during his Oval Office meeting with German Chancellor Friedrich Merz on March 3, 2026. The meeting addressed sensitive topics, including Iran, trade, NATO burden-sharing, and relations with European allies, making it a substantive example of contemporary presidential political discourse. Employing qualitative discourse analysis and linguostylistic interpretation within a single-text case study design, the study identifies the main stylistic devices observed in Trump's remarks, including evaluative vocabulary, repetition, contrast, intensification, colloquialism, threat rhetoric, parallelism, and metaphor. Particular attention is given to the Spain-related segment, where evaluative language, binary opposition, and coercive framing co-occur. The analysis indicates that Trump's spontaneous discourse is characterized by emotional directness, simplified syntactic organization, and strong persuasive framing. Unlike scripted presidential speeches, these remarks exhibit a more immediate and interactional rhetorical style, yet they appear to perform identifiable ideological and strategic functions. As a single-case analysis, the findings are not intended to be generalized beyond the analyzed text; rather, the study contributes to a growing body of research suggesting that spontaneous presidential discourse warrants focused scholarly attention for its capacity to reveal how stylistic choices operate in real-time political communication.*

Keywords: *political discourse, linguostylistics, Donald Trump, foreign-policy rhetoric, stylistic devices, case study*

[1]Nakhchivan State University, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: alisoyhasan@ndu.edu.az
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"Tramp–Merz görüşü zamanı Trampın spontan xarici siyasət bəyanatlarının linqvostilistik təhlili: nümunə tədqiqatı"

Həsən Əlisoy[1*], İlhamə Məmmədova[1], Yasin Babazadə[1], Zərifə Sadiqzadə[1], Elnaz Əliyeva[1]

Xülasə. *Bu məqalə Donald Trampın 2026-cı il mart ayının 3-də Almaniya kansleri Fridrix Merts ilə Oval Kabinetdə keçirdiyi görüş zamanı səsləndirdiyi spontan xarici siyasət çıxışlarının linqvostilistik xüsusiyyətlərini araşdıran bir hal tədqiqatı (case study) təqdim edir. Görüşdə İran, ticarət, NATO yük bölgüsü və Avropa müttəfiqləri ilə münasibətlər kimi həssas mövzular müzakirə olunmuşdur. Tədqiqatda keyfiyyət diskurs təhlili və linqvostilistik interpretasiya üsullarından istifadə edilmişdir.*

Trampın çıxışlarında müşahidə olunan əsas üslubi vasitələr, o cümlədən qiymətləndirici leksika, təkrar, kontrast, intensivləşdirmə, danışıq üslubu, təhdid ritorikası, paralelizm və metafora müəyyən edilmişdir. Təhlil göstərir ki, Trampın spontan diskursu emosional birbaşalıq, sadələşdirilmiş sintaktik təşkil və güclü inandırıcı çərçivələmə ilə səciyyələnir. Bir hal tədqiqatı olaraq, nəticələr təhlil edilmiş mətnin hüdudlarından kənara ümumiləşdirilmək üçün nəzərdə tutulmamışdır; əksinə, tədqiqat spontan prezident diskursunun real vaxt siyasət kommunikasiyasında üslubi seçimlərin necə işlədiyini aşkar etmə potensialına malik olduğunu göstərən artan elmi ədəbiyyata töhfə verir.

Açar sözlər: *siyasət diskursu, linqvostilistika, Donald Tramp, xarici siyasət ritorikası, üslubi vasitələr, hal tədqiqatı*

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[1]Naxçıvan Dövlət Universiteti, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: alisoyhasan@ndu.edu.az
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Introduction

Political discourse analysts emphasize that spontaneous speech by leaders can reveal pragmatic and ideological functions not always visible in scripted addresses (Chilton, 2004; van Dijk, 1997; Wodak & Meyer, 2023). The March 3, 2026 Oval Office meeting between U. S. President Donald J. Trump and German Chancellor Friedrich Merz provided a compact corpus of unscripted presidential foreign-policy discourse. According to news accounts, this meeting took place against the backdrop of U. S. –Israeli strikes on Iran and rising international trade tensions (Bose et al., 2026). In off-the-cuff remarks captured on the official White House video and transcript (Trump, 2026; The White House, 2026), President Trump addressed issues such as NATO burden-sharing, the use of Spanish military bases for Iran operations, and recent tariff policies.

While previous analyses have predominantly focused on formal speeches such as inaugural addresses and joint sessions of Congress (Charteris-Black, 2011; Fairclough, 1995), the Trump–Merz exchange is valuable precisely because it is interactional and extemporaneous. As reported by Reuters, Trump threatened to terminate trade relations with Spain after its refusal to allow U. S. use of its bases (Bose et al., 2026). The present study seeks to answer the following research question: What are the prominent stylistic devices in Trump's March 3, 2026 Merz-meeting remarks, and how do they function rhetorically?

Based on prior scholarship, the analysis anticipates observing frequent evaluative adjectives, repetition, and informal language consistent with Trump's established rhetorical persona (Charteris-Black, 2011; Fairclough, 1995; Wodak, 2011; Breeze, 2021). The study further examines how these devices may contribute to the expression of authority, persuasion, and ideological positioning (Beard, 2000; Chilton, 2004; Hart, 2021).

It is important to note that this study constitutes a single-case analysis based on one transcript. Accordingly, the findings are descriptive and exploratory in nature and are not intended to be generalized beyond the analyzed text. The study is framed explicitly as a case study designed to illustrate how linguostylistic methods can be applied to spontaneous political discourse.

Literature Review

The linguistic study of political discourse has a long and well-established tradition. Van Dijk (1997) defined political discourse analysis as the examination of text and talk in political contexts,

emphasizing that political language performs both ideological and strategic functions. Chilton (2004) extended this framework by proposing that political discourse operates along axes of coercion, legitimization, representation, and misrepresentation. These foundational works have informed subsequent research on how leaders employ language to construct authority and manage public perception.

Critical Discourse Analysis (CDA), as developed by Fairclough (1995) and systematized in subsequent methodological guides (Wodak & Meyer, 2023; Flowerdew & Richardson, 2023), provides the analytical tools for examining the relationship between language, power, and ideology. In CDA, linguistic features such as evaluative vocabulary, modality, and presupposition are understood as discursive strategies that enact social relations. Machin and Mayr (2023) further operationalized CDA methodology by offering practical frameworks for identifying how lexical choices, transitivity patterns, and rhetorical structures encode power relations in public discourse.

Within the specific domain of political rhetoric, Beard (2000) examined the "language of politics" and identified patterns of evaluation, persuasion, and condemnation that recur across political speech genres. Charteris-Black (2011) focused on the role of metaphor in political persuasion, demonstrating that figurative language serves to simplify complex policy positions and construct emotionally resonant narratives. More recently, Cap (2022) developed proximization theory, which explains how politicians use spatial, temporal, and axiological strategies to construct perceived threats and justify policy responses.

Research specifically addressing Trump's discourse has grown considerably. Breeze (2021) analyzed populist rhetorical positioning across political parties, identifying patterns of binary framing and anti-elite sentiment. Hart (2021) examined metaphorical framing in political discourse, demonstrating how figurative language shapes audience perception of social groups. Sclafani (2018) provided a comprehensive analysis of Trump's linguistic style, noting the prevalence of evaluative adjectives, hyperbole, repetition, and colloquial register as defining features of his rhetorical identity.

Linguostylistic analysis, drawing on foundational work by Leech and Short (2007) and further developed in Jeffries and McIntyre (2010), offers a complementary approach to CDA by focusing on the formal properties of style—such as lexical choice, syntactic patterning, and figurative language—and examining how these properties create meaning in context. This approach is particularly suitable for analyzing the aesthetic and performative dimensions of political speech, including spontaneous discourse where the absence of scripted polish reveals a speaker's default stylistic preferences.

Despite the growing body of literature on political discourse, relatively few studies have examined spontaneous, unscripted presidential remarks as a distinct genre. Most existing research focuses on prepared speeches—inaugural addresses, State of the Union addresses, campaign rally scripts—which are designed and edited to achieve specific rhetorical effects (Charteris-Black, 2011; Flowerdew & Richardson, 2023). The present study addresses this gap by applying linguostylistic analysis to a single instance of spontaneous presidential discourse, framed as a case study to explore the analytical potential of this approach.

Research Design and Methodology

3.1 Research Design

This study adopts a qualitative case study design (Yin, 2018) focused on a single text: the official transcript of President Trump's remarks during the bilateral meeting with Chancellor Merz on March 3, 2026 (Trump, 2026). Case study methodology is appropriate when the aim is to conduct an in-depth exploration of a bounded phenomenon within its real-world context (Yin, 2018). As this

analysis is based on a single transcript, the findings are understood as observations specific to the analyzed text and are not intended for generalization to other instances of presidential discourse.

3.2 Corpus Selection

The corpus consists of the official transcript covering all on-record verbal exchanges between Trump, Merz, and reporters. The analysis focuses specifically on Trump's turns, which account for approximately 80% of the total word count. Contextual reporting by Reuters (Bose et al., 2026), AP News (Hussein & Naishadham, 2026), and Euronews (Wright, 2026) was consulted to establish the situational context of the meeting. No additional data sources (e. g., audio recordings) were required for the purposes of this stylistic analysis.

3.3 Annotation Procedure and Coding Reliability

The transcript was read in full and annotated for occurrences of stylistic devices, informed by established categories in political discourse stylistics (Chilton, 2004; Jeffries & McIntyre, 2010; Leech & Short, 2007). Each clause was coded for the following features: evaluative adjectives, repetition of words and phrases, binary contrast structures, intensifiers, informal or idiomatic language, metaphors, parallel constructions, and threat-related statements. All coding decisions and category definitions were documented to ensure procedural consistency.

Given that coding was performed by a single researcher, the question of reliability warrants explicit discussion. Following Schreier (2012), who notes that in qualitative content analysis involving a single coder, consistency can be supported through theory-driven coding categories and systematic documentation, the present study employed coding categories derived directly from established theoretical frameworks: Chilton's (2004) categorization of political discourse strategies, Jeffries and McIntyre's (2010) stylistic analysis toolkit, and Leech and Short's (2007) framework for stylistic features. Each identified instance was cross-checked against the original transcript to verify accuracy. Where ambiguity arose regarding the classification of a given expression, the coding decision was resolved by reference to the theoretical definitions provided in the source frameworks. While the absence of inter-coder reliability measures constitutes a limitation, the use of theoretically grounded categories and transparent documentation supports the dependability of the analysis within the scope of this case study.

3.4 Analytic Framework

The analysis draws on linguostylistics and discourse analysis frameworks for political text (Beard, 2000; Fairclough, 1995; van Dijk, 1997; Wodak & Meyer, 2023). The approach is qualitative with quantitative supplementation: devices were identified qualitatively, and their occurrences were subsequently counted. A simple coding scheme was employed in which each identified instance of a device type was tallied. Devices were coded as separate categories, permitting multiple codes per sentence.

3.5 Ethical Considerations

The data consist entirely of publicly available material (a presidential speech transcript and published news articles). No human subjects or personal data are involved. All quotations are properly cited.

Results

The coding procedure identified the following stylistic devices in Trump's Merz-meeting remarks. Each device is described below with illustrative quotations and frequency counts (Table 1). It should

be noted that the frequency values reported in Table 1 reflect exclusively the analyzed transcript and should not be interpreted as indicative of broader patterns in presidential or political discourse.

Evaluative vocabulary. Trump frequently employs positive adjectives for certain allies and negative ones for others. For instance, the Dutch Prime Minister and NATO head are described as "fantastic," while Germany is characterized as "great" and "terrific" (Trump, 2026). By contrast, Spain is described as "terrible" and "unfriendly," though Trump distinguishes between its people ("great people") and its leadership ("not great leadership") (Trump, 2026). This evaluative polarization functions to differentiate allies perceived as cooperative from those perceived as uncooperative. The analysis identified 18 evaluative adjectives and adverbs in the transcript.

Repetition. Trump frequently restates ideas in slightly modified form. For example, the sequence "We could use their base… We could just fly in and use it" (Trump, 2026) repeats the modal structure to emphasize U. S. capability. Similarly, "They have great people… but they don't have great leadership" (Trump, 2026) employs a parallel template. Such anaphoric repetition appears to function as a rhetorical reinforcement strategy. Approximately 4 instances of notable repetition or parallel phrasing were identified.

Contrast and binary opposition. The remarks construct clear oppositions: "fantastic" Germany is juxtaposed with "terrible" Spain (Trump, 2026); "great people" is contrasted with "not great leadership" (Trump, 2026); "helpful" European nations are set against those characterized as unhelpful (Trump, 2026). These binary structures appear to function as a mechanism for constructing in-group and out-group categories among allies. The analysis identified 6 contrastive pairs.

Intensification and hyperbole. Strong intensifiers and hyperbolic expressions are observable, including "absolutely nothing" (Trump, 2026), "massive amounts of ammunition" (Trump, 2026), "unlimited supply" (Trump, 2026), and "tremendous amount" (Trump, 2026). These expressions appear to function as amplifiers of evaluative and assertive statements. Five intensifiers and hyperboles were noted.

Colloquialism and informal register. The discourse contains informal and colloquial expressions, including characterizing adversaries as "lunatics" (Trump, 2026), describing policy decisions as "stupidly" executed (Trump, 2026), and employing vivid conversational imagery. Such register choices are consistent with patterns of informality identified in Trump's discourse by prior scholarship (Sclafani, 2018; Breeze, 2021). Four colloquial or informal expressions were identified.

Threat rhetoric and coercive framing. Trump makes explicit statements of threatened political and economic action. Most notably, he states "we're going to cut off all trade with Spain. We don't want anything to do with Spain" (Trump, 2026). These statements function as coercive pressure directed at an ally perceived as non-compliant. Two instances of explicit threat rhetoric targeting Spain were identified.

Metaphor. A small number of metaphoric expressions were observed. The most notable is "They were the kings and fathers of the roadside bomb" (Trump, 2026), which personifies Iranian operatives through royal and paternal imagery to characterize their role in asymmetric warfare. Two metaphors were identified in total.

Parallelism. Parallel syntactic structures appear occasionally. For instance, regarding former Chancellor Merkel, Trump states "he's pretty much the opposite of her on energy and the opposite on immigration" (Trump, 2026), employing a repeated "the opposite on…" construction. Two instances of clear parallel phrasing were identified.

Deixis and direct address. The transcript contains deictic references and instances of direct address. For example, "this is not Winston Churchill that we're dealing with" (Trump, 2026) uses deictic "this" to reference the Spanish leadership situation. Two instances of notable deictic reference or direct address were identified.

Table 1
Frequency of Stylistic Devices Identified in Trump's March 3, 2026 Merz Meeting Remarks

Device	Frequency
Evaluative adjectives	18
Repetition/Parallelism	4
Contrast/Opposition	6
Intensification/Hyperbole	5
Colloquialism/Informal register	4
Threat rhetoric	2
Metaphor	2
Deixis/Direct address	2

Note. Frequency counts reflect only the analyzed transcript (Trump, 2026) and are not generalizable to other instances of presidential or political discourse. Categories are not mutually exclusive; a single sentence may be coded under multiple device types.

To illustrate the co-occurrence of devices, the Spain-related passage merits particular attention: "Spain has absolutely nothing that we need other than great people. They have great people, but they don't have great leadership… So we're going to cut off all trade with Spain. We don't want anything to do with Spain" (Trump, 2026). This passage exhibits evaluative vocabulary ("great, " "leadership"), intensification ("absolutely nothing"), binary contrast ("great people" vs. "not great leadership"), repetition ("Spain" repeated four times), and explicit threat rhetoric ("cut off all trade"). The co-occurrence of multiple devices within a single passage suggests a pattern of rhetorical layering in which stylistic choices work in combination to construct political pressure.

Discussion

The analysis illustrates how Trump's extemporaneous remarks at the Merz meeting are characterized by a distinctly informal and confrontational style in comparison to what might typically be expected in a prepared address. The density of evaluative and coercive language is consistent with what Beard (2000) identifies as the "language of condemnation" in political rhetoric, wherein lexical choices function to construct and reinforce evaluative hierarchies among political actors.

Compared to formal speeches, spontaneous discourse appears to permit a greater degree of personal voice and colloquial register. The Merz meeting remarks contain incomplete sentences, colloquial characterizations, and direct asides that would be atypical in a carefully edited speech. This observation is consistent with findings by Chilton (2004) and Wodak (2011), who note that interactive political talk frequently foregrounds personal stance and communicative immediacy.

The observed patterns are consistent with documented features of Trump's rhetorical style, including persuasive repetition, evaluative emphasis, and colloquial register (Sclafani, 2018; Breeze, 2021). However, in the analyzed transcript, these devices appear to be deployed in real time in response to contextual factors—specifically, the Iran conflict and journalist questions—rather than as elements of a preplanned rhetorical agenda. The discourse thus exhibits a mixed character, combining elements

of formal presidential communication (references to NATO goals, technical military details) with informal and occasionally colloquial expression.

It is important to exercise caution in interpreting these findings. The identified patterns represent observations within a single text and should be understood as associations between stylistic features and apparent communicative functions, rather than as causal claims about rhetorical intention. For example, while the evaluative and threatening language directed at Spain co-occurs with what appears to be a coercive communicative function, the present analysis cannot establish that the speaker deliberately selected these devices for that purpose. The relationship between linguistic form and pragmatic function in spontaneous speech is inherently complex (Chilton, 2004; Jeffries & McIntyre, 2010).

From the perspective of political communication, the analysis suggests that studying naturalistic interactions may offer insights into how political leaders communicate unscripted messages. As contemporaneous reporting indicates, these particular remarks generated substantial media coverage (Wright, 2026; Hussein & Naishadham, 2026). The linguistic features identified—vivid evaluative language and overt threat statements—are consistent with characteristics that tend to attract journalistic attention. For scholars of political discourse, this case illustrates that speech genre matters: an Oval Office bilateral meeting is neither a press conference nor a formal address, but an impromptu interactional event that can be productively analyzed for its stylistic properties.

The limitations of this study should be acknowledged. As a single-case analysis, the findings cannot be extrapolated to presidential discourse more broadly. The use of a single coder, while supported by theoretically grounded categories, represents a methodological constraint. Future research employing multiple coders and larger corpora would enhance the reliability and generalizability of similar analyses.

Conclusion

This case study has examined the linguostylistic features of Donald Trump's spontaneous remarks during the March 3, 2026 meeting with German Chancellor Friedrich Merz. The analysis identified a pattern of evaluative, repetitive, and confrontational stylistic devices, including evaluative adjectives, binary contrasts, intensifiers, colloquialisms, threat rhetoric, metaphors, and parallel structures. The frequency analysis (Table 1) indicates that evaluative and emphatic expressions are the most prominent features in the analyzed text.

The findings suggest that spontaneous presidential discourse is characterized by features that differ from those typically observed in scripted addresses, including greater informality, more direct evaluative language, and reactive rather than preplanned rhetorical strategies. As a single-case study, these findings are descriptive and exploratory; they are not intended to be generalized beyond the analyzed transcript. Nonetheless, the analysis contributes to a growing body of research indicating that spontaneous political discourse warrants focused scholarly attention for its capacity to reveal how stylistic choices operate in real-time communication.

Future research could extend this framework to other unscripted interactions, such as press events and bilateral meetings involving different political leaders. Comparative studies examining spontaneous discourse across different contexts, time periods, or political figures could contribute to a more systematic understanding of how personal style interacts with situational factors in political rhetoric. Additionally, combining qualitative linguostylistic analysis with corpus-based quantitative methods could offer a more comprehensive profile of stylistic patterns in presidential discourse.

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An Evaluation of Hasan Yavas's Life Works and The Islam and Faith Sections of His Book Called "Guide Catechism"

Erdogan Koycu

Abstract. *This study aims to examine the sections on "Islam and Faith" in Rehber İlmihâli (Guide Catechism) by Hasan Yavaş. Yavaş, who wrote five hundred and forty-eight columns and five books. He currently writes columns for Türkiye Newspaper and produces Ramadan programs for TGRT. Yavas has written five works: "Catechism for Everyone", "Prayer Book," "Guide Catechism", "Guide for Women," and "Great Women of Islam and a Guide for Young People." He has compiled his "Guide Catechism" in ten chapters. We conducted our research on the following topics: "Advice for Young People" and "How to be a Good Muslim?" in the introduction. "Youth should be appreciated," he addresses in the first chapter, "Islam, the beautiful religion," and "What should our faith be like?" in the second. Yavas attempts to explain the fundamental principles of faith and the foundations of worship in a simple language in his work. Our research examines Hasan Yavas's life and works, as well as the "Islam and Faith" section of the Guide Catechism. The factor that motivated Yavas to write Guide Catechism is the fundamental principle mentioned in The Holy Quran and hadith: "al-emri bi al-maruf va al-nehyi al-munkar" (enjoining what is right and forbidding what is wrong). Hasan Yavaş's work, Guide Catechism, appeals to a broad audience because it addresses issues of faith, worship, conduct, and morality. Despite its numerous editions, both domestically and internationally, the lack of any book, article, or paper addressing the Guide Catechism paved the way for this research.*

Keywords: *hadith, Catechism, text, comment, Hasan Yavas*

Bartın University, Bartın, Turkey
E-mail: ekoycu@bartin.edu.tr
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Həsən Yavaş'ın "Rehber Ilmihali" əsərində həyatının əsərlərinin və İslam və iman bölmələrinin qiymətləndirilməsi

Erdoğan Köycü

Xülasə. *Həsən Yavaş Dini İşlər Başkanlığından təqaüdə çıxmış müftidir. O, 548 qəzet köşəsi və beş kitabın müəllifidir. Hal-hazırda Türkiyə Gazetesi üçün köşə yazıları yazır və TGRT-də Ramazan proqramlarına aparıcılıq edir. Müəllifidiritabın müəllifidir: "Hər kəs üçün Rehber Elmihal", "Dua Kitabı", "Rehber Elmihal", "Qadınlar üçün bələdçi məlumatı" və "Böyük İslam Qadınları və Gənclər üçün bələdçi". O, "Rehber Elmihal"ı on bölmədən ibarət yazıb. Tədqiqatımızı onun girişdə toxunduğu mövzular əsasında apardıq: "Gənclərə nəsihət", "Yaxşı müsəlman necə olmalı?" və "Gəncliyin dəyəri bilinməlidir", birinci hissədə: "Gözəl dinimiz İslam", ikinci hissədə: "İmanımız necə olmalıdır?" Yavaş "Rehber İlmihali" (İslam Hüququna Bələdçi) əsərində imanın təməl prinsiplərini və ibadətin əsaslarını sadə bir dildə izah etməyə çalışır.*

*Bu tədqiqat Həsən Yavaşın həyatına, əsərlərinə və "Rehber İlmihali" əsərinin "İslam və İman" bölməsinə yönəlmişdir. Yavaşın "Rehber İlmihali" əsərini yazmasının əsas hərəkətverici qüvvəsi Quran və hədislərdə qeyd olunan təməl prinsipdir: "əl-əmr bil-mə'ruf vən-nəhy anil-munkər" (yaxşılığı əmr etmək və pisliyi qadağan etmək). Həsən Yavaşın "Rehber İlmihali" əsəri inanc, ibadət, müamilə və etika kimi mövzuları əhatə etdiyi üçün geniş auditoriyaya müraciət edir. Həm ölkə daxilində, həm də beynəlxalq səviyyədə çoxsaylı nəşrlərə baxmayaraq, Rehber İlmihali mövzusunda heç bir kitabın, məqalənin və ya konfrans materialının olmaması bu tədqiqatın əsasını təşkil etmişdir. Yavaşın "İslam Hüquqşünaslığına Bələdçi" əsərində kitabların müəlliflərini və adlarını qeyd edərək istinad etdiyi mənbələr bunlardır: İmam əl-Rabbani əs-Sərhəndi (vəfat tarixi 1033/1624) tərəfindən əl-Məktubatın tərcüməsi; Şeyxülislam Əhməd Namiqi Caminin "Miftah əl-Nəcāt" əsəri; Professor Karlaylın Konfransı, və Beoworth Smithin "Məhəmməd və Onun ardıcılları". Yavaş bu mənbələrdən və onların müəlliflərindən bəhs etsə də, bu kitablarda sitatların yer aldığı konkret səhifələri göstərmir. Yavaş, ayələri sitat gətirərkən surə və ayə nömrələrini "Uca Allah buyurur" qeydi ilə daxil edərkən, hədislərə istinad edərkən "Sevgili Peyğəmbərimiz dedi", "Peyğəmbər dedi", "Allahın Rəsulu dedi", "Hədisdə deyilmişdir" və "Sevgili Peyğəmbərimiz xəbər verdi" kimi ifadələrdən istifadə edərək, bir hədis və ya hekayədəki müqəddəs bir hədisdən dəlil gətirir. Yavaş mövzuları izah edərkən yalnız ayə və hədislərdən sitat gətirməklə kifayətlənməyib, bəzən hekayələrdən, şeirlərdən və aforizmlərdən sitatlar da daxil edib. Yavaş'ın Rehber İlmihali adlı kitabının İslam və İman bölmələrində qaynaq olaraq göstərilən hədislərə ümumiyyətlə *Əl-Kutub əs-Sitte* toplularında rast gəlinir: *Əl-Cami əl-Səhih*, Məhəmməd b. İsmayıl əl-Buxari (vef. 256/870), *Əl-Cami əl-Səhih*, Müslim b. əl-Həccac (vefat. 261/874), *Əs-Sünən*, İbn Macə Əbu Əbdillah Məhəmməd b. Yezid (vef. 273/886), *Əs-Sünən*, Əbu Davud Süleyman b. əl-Əşas (vəf. 275/888) və *əl-Məhəmməd b. Bu hədislərə İsa əl-Tirmizi'nin (vəf. 279/892) Əs-Sünən'ində və Altı Hədis Kitabından kənarda, Əhməd ibn Hənbəlin (vəf. 242/855) Müsnədində və Abdullah ibn Əbdürrəhman əd-Dariminin (vəf. 255/869) Sünənində rast gəlinir. Həsən Yavaş mövzuların izahında bu əsərlərdən sitat gətirsə də, mənbələrə istinad etmir. Biz bu hədislərin mənbələrini müəyyən etdik. O, həmçinin istinad etdiyi hədislərə qısa şərhlər verir.*

Açar sözlər: *hədis, İslam fiqhi, mətn, şərh, Həsən Yavaş*

Bartın Universiteti, Bartın, Türkiyə
E-poçt: ekoycu@bartin.edu.tr
Daxil oldu: 14 Yanvar 2026; Qəbul edildi: 16 Mart 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

Hasan Yavaş is a retired mufti from the Presidency of Religious Affairs. Besides writing a column for the Türkiye newspaper, he has been hosting Ramadan programs on TGRT since 2018. He has authored five books. We believe that Yavaş's aim goes beyond simply writing methodical and systematic scholarly works; it is to be helpful to the reader. The central claim of our research is to determine whether the hadiths used to explain the topics in Hasan Yavaş's *Rehber İlmihâli (Guide Catechism)* are taken from their sources.

The hadiths that Yavas cites as sources in the Islam and Faith sections of his *Guide Catechism* book are generally in the *al-Jami's-Sahih of Muhammad İbn Ismail al-Bukhari* (d. 256/870) who is famous with the name *al-Kutub al-Sitta*, in the *al-Jami's-Sahih of Muslim ibn al-Hajjaj* (d. 261/874), in the *al-Jami's-Sahih of Ibn Majah Abu Abdullah Muhammad ibn Yazid* (d. 273/886), in the *al-Sunan of Abu Dawud Suleyman ibn al-Ash'as* (d. 275/888), in the *al-Sunan of Muhammad ibn İsa al-Tirmidhi* (d. 279/892) and in the *Musnad of Ahmad ibn Hanbal* (d. 242/855) which is included in the *Sunan* of *Abdullah ibn Abdirrahman al-Darimi* (d. 255/869) apart from *al-Kutub al-Sitta*. Although Hasan

Yavas quoted from these works in his explanations of the topics, he did not cite their sources. We have identified the sources of these hadiths. He also occasionally provided brief commentaries on the hadiths he cited.

The aim of Hasan Yavaş's "*Guide Catechism*" and other authors of Islamic catechisms in writing these works is to contribute to the betterment of both their own lives and the lives of society. We can summarize this as follows. "When we say religion, we mention good morals. In other words, if religion is called pure and entirely consisting of beautiful morals, it won't be wrong. Because it's entirely composed of ethical principles. The real purposes of faith, worship, transactions of war, peace, and all other activities are to achieve a moral human and thereby a moral society. As the main target of gaining moral values in the verbal and formal fields, human beings are trained through religious rituals. It aims to build personalities that will represent themselves successfully at every level through these kinds of realities, while also pursuing not the practice itself but the values it yields. (Okumuş, 2015, pp. 234–235).

Our research is original. Some studies have been conducted on other Islamic catechisms written before or after Hasan Yavaş's authorship of the Rehber İlmihâli. In the Literature section of our research, we have listed these studies by name, as far as we could ascertain. Since separate research could be conducted for each catechism, we have not included details for each catechism. Our research focuses specifically on the sources Hasan Yavaş used in authoring his Islamic catechism, the sources he cited for hadith texts, and their interpretation, as no existing scholarly study examines these aspects.

Background History Review of Literature

Islamic catechisms are indispensable resources for organizing a Muslim's daily life. For this reason, many Islamic catechisms have been written.

Similar to our research on the Islam and Faith sections of Yavaş's work titled "*Guide Catechism*," a doctoral thesis has been prepared on catechisms. In the dictionary, "İlm-i Hâl" means "knowledge of conduct". In terms of terminology, it is a "handbook" containing concise information on matters of faith, worship, daily life, ethics, and, occasionally, on major prophets and the life of the Prophet Muhammad." (Arpaguş, 2000, p. 22/139). Written during the Ottoman period. Articles and papers have also been written and presented on some religious handbooks authored during the Republican era. Some research has also been published on the following works: Mustafa Asım Köksal (ö. 1418/1998), *Gençlere Din Kılavuzu* (Köksal, 2006, pp. 1–206). This work, which is in the nature of a catechism, is embellished with poems in places. This work was later expanded and published as a catechism in 1954 and as an "Islamic Catechism" in 1977 (Yapıcı, 2021, p. 22); Ali Efendi's (d.?), *Manzûm İlmihâli* (Süslü, 2019, pp. 2(3)/165-183). It is mentioned that there is no information about the author in the sources and that the work is registered in the Hacı Selim Ağa Library, Kemankeş section, under number 681 (Kırkıl, 2006, p. 7/440). *Umdetu'n-Nisâ.* It is believed that this work, which contains jurisprudential issues related to matters specific to women (National Library, no. 153/3; Süleymaniye Library, Hacı Mahmud Efendi, no. 562, 1038), is the first women's catechism written in Ottoman Turkish (Telkenaroğlu, 2019, pp. 693–694). Other manuscripts of the work: National Library, Manuscripts, 06 Mil Yz A 2421, 1a33a. İnebey Manuscript Library, General Collection, 62/3, 41b-76a) Çorum: Provincial Public Library, Çorum Hasan Paşa Provincial Public Library, 19 Hk 1507/3, 32b-103a. (Özbay & Altunbay, 2023, pp. 503–528) Zileli Muharrem Efendi's (d. after 1601) *İbrahim Hakkı Erzurumi*'s (d. 1194/1780) *Manzûm İlmihâli* (Memduhoğlu, 2015, pp. 11–52). Manastırlı Mehmet Rıfat Bey's (d. 1325/1907) *Manzûm İlmihâli* It has been stated that the work is purely educational, far removed from literature and art, and that its primary purpose is "not to display skill, but to render a service by easily conveying the essence of the Divine Moon

unforgettably." (Kırkıl, 2006, 7/444). Mehmet Zihnî Efendi's (d. 1331/1913) *Ni'met-i İslâm* (Köycü, 2021, pp. 1357−1367*).*; Ömer Nasûhî Bilmen's (d. 1391/1971) *Büyük İslâm İlmihâli* (Köycü, E. 2017, pp. 3140−3167); Dinin Amelî Hükümlerinin Mükelleflere Aktarımında İlmihâl Dili ve Önemi-Ömer Nasuhi Bilmen'in Büyük İslâm İlmihâli Örneği, (Çetinkaya, 2019, pp. 620−630); Mustafa Asım Köksal's İslâm İlmihâli İman İbadet ve Ahlâk Esasları (Köksal, 2021, pp. 1−256). "Ömer Nasuhi Bilmen'in Büyük İslâm İlmihâli'nde Toplumsal Cinsiyet", (Esra, 2023, pp. 203−234); "Fıkhî Problemlerin Çözümünde İhtilâfların Zikredilmesi "Büyük İslâm İlmihâli Örneği", (Atan, 2023, pp. 321−349). And "Gaziantepli Seyyid Muhammed Ali Rıza's *Manzûm İlmihâli* Titled *Hakîkatü'l-Envâr"* (Kayalık Şahin, 2021, pp. 1071−1120).

Methods

This research is a qualitative study that analyzes the sections on Faith and Islam in Hasan Yavas's work, "Guide Catechism," from an analytical and methodological perspective. Our fundamental research methodology focuses on the following questions: What is the source value of the work? What sources did he use? What methodology did he employ in using these sources? Did he simply copy the information from the sources or interpret it?

The research utilized Ouran, hadiths, and classical and modern academic studies as data sources. The data obtained within this framework were examined using a textual analysis method, without adhering to any ideological preconceptions. Quranic verses and hadiths were interpreted in their contexts, and their potential to serve as a direct normative model.

In conclusion, this research is grounded in historical data and employs a critical, interpretive methodological framework, supported by textual analysis and comparative readings.

Our research consists of three main sections. The first section covers Yavaş's life and works. The second section examines why he authored his work. In the third section, we will identify the sources of the *Guide Catechism*, both those mentioned by the author and those not mentioned, and explore the sources of the hadiths cited in the Islam and Faith sections of the Guide to Islam and how Yavaş interpreted them. In the writing of these sections, description, commentary, and critical perspective will be prioritized.

Life and Works

Hasan Yavaş is a retired mufti who served for many years at the Directorate of Religious Affairs. He is a columnist for the Turkish newspaper Türkiye. Since 2018, he has been preparing and presenting the "Sahur Vakti with Hasan Yavaş on TGRT" program. Yavaş has authored five works on Islam, religious practices, and prominent Muslim women.

1. *Catechism for Everyone* (İstanbul: Babıali Kültür Publication, 2005).
2. *Prayer Book (Kitab al-Salât)* (İstanbul: Berakât Publication, 4th Edition, 1977). Other Editions: (İstanbul: Hakikat Publication, 1998); (İstanbul: Hakikat Bookstore, 2000); (İstanbul: Berakât Publishing House, 5th Edition, 2006); (İstanbul: Hakikat Bookstore, Fifth Edition, 2006); (İstanbul: Hakikat Bookstore, 107th Edition, 2012). http://worldcat.org/formats-editions/1006653404 (Accessed 12 February 2025).
3. *Guide Catechism* (İstanbul: İhlas Printing and Distribution, 1986). Another Edition: (Almanya, Dortmund: Serhend Bookstore, 2008).
4. *Guidelines for Women and Great Islamic Women* (İstanbul: Fazilet Publication, 2006); Other Editions: (İstanbul: İhlas Journalism, 2015); (İstanbul: Pencereler Publication, 2019).
5. *Guide for Young People* (İstanbul: Pencereler Publishing House, 2019).

The Purpose of Writing the Work Titled "*Guide Catechism.*"

Hasan Yavaş begins his work, "*Guide Catechism,*" with praise and thanksgiving to Allah and salutations to our Prophet. He emphasizes that humans desire to live in comfort and peace, wish for lasting happiness, strive for immortality, and endeavor to fulfill all their desires without difficulty or hardship, but that achieving these desires is not possible in this worldly life (Yavaş, 2008, p. 3).

Yavaş pointed out that Allah Almighty created humanity to test them, and that this test involves blessings and burdens, good and evil, virtue and vice, intertwined. He also noted that scholars who followed the prophets guided and directed people. He emphasized that the prophets explained Allah Almighty's commands, prohibitions, desires, and disapprovals to humanity, underscoring that humankind has never been left without guidance in any era (Yavaş, 2008, p. 3).

Yavaş emphasized that Allah Almighty sent religions to humanity as a kind of medicine, a prescription, so that people could find comfort and peace in this world and the hereafter. He stated that religions are the path of Allah Almighty, and that anyone who obeys His commands and prohibitions can find comfort in this world, and that those who wish to be saved in the hereafter must believe in him and use the remedies he has revealed. He stressed that those who obey Allah Almighty's commands and prohibitions will attain the blessings and happiness he has promised in the hereafter (Yavaş, 2008, p. 4).

Yavaş stated that the religions sent by Allah Almighty have been altered over time by tyrants and the self-indulgent, causing their original forms to be forgotten, and that humans have introduced ideas of their own, establishing incorrect and incomplete rules. The Messenger of Allah (p.b.u.h.) also ordered Zayd b. Sabit (d. 45/665) to learn the Jewish script and stated that he did not trust what a Jewish scribe had written (Abu Dawud, 1992, "İlim", 5); (et-Tirmidhi, 1992, "İsti'zân", 28). He emphasized that the final religion conveyed by every prophet since Adam (p.b.u.h.) is the true and uncorrupted religion, and that Islam is the true religion that must be followed (Yavaş, 2008, p. 4).

Yavaş stated that Islam first commands belief, and that those who have even a trace of faith and die with faith will surely be saved and go to Paradise. He also noted that Allah Almighty will forgive their shortcomings in worship and their sins, and if he wishes, he will punish them for a while before admitting them to Paradise (Yavaş, 2008, p. 4).

Yavaş pointed out that Islam consists of obeying Allah Almighty's commands and avoiding His prohibitions, emphasizing that the maturity of faith and its acceptance by Allah Almighty depend on the beauty of one's character. He mentioned that our religion commands us to be kind, cheerful, and sweet-spoken to everyone, meaning to avoid hurting or breaking anyone's heart, and to do good to everyone, regardless of whether they believe or not. He also stated that just as "a sweet tongue can charm a snake out of its hole," bad character can lead one astray from faith (Yavaş, 2008, p. 4).

Yavaş emphasized that for every Muslim who believes in the existence and oneness of Allah Almighty and the prophethood of Prophet Muhammad (p.b.u.h.), knowing the six pillars of faith is a prerequisite for being a Muslim, and that they must also learn the conditions of Islam and fulfill their religious duties (Yavaş, 2008, p. 5).

Yavaş, emphasizing the importance of Muslims learning what constitutes "good morals" and "bad morals" to rid themselves of bad habits and cultivate good character, stated that treating a disease is only possible by first diagnosing it and then using its medicine. In this context, he noted that he prepared a book he named "Guide to Islamic Catechism" so that our precious children and young people can briefly learn about and live according to our beautiful religion, Islam (Yavaş, 2008, p. 5).

Sources Used in the Writing of the Work Titled "*Guide Catechism.*"

Hasan Yavaş listed the names of thirteen sources he used in writing his work titled Rehber İlmihâl at the end, but did not mention the authors of those works. We have identified the authors of the works.

1. Ebû Hâmid el-Gazzâlî (d. 505/1111), *Kimyây-ı Seâdet* H. A. Homes translated the work into English as The Alchemy of Happiness (Albany: 1873), based on the Turkish translation by Mustafa Efendi of Van (Süleymaniye Library, Hagia Sophia, nos. 1719, 1720, 2026; Dresden Library, no. 15; Uppsala Library, no. 460). It was re-translated into Turkish by A. Faruk Meyan (Istanbul: 1979)." Karlığa, (1996). *Turkish Religious Affairs Foundation Encyclopedia of Islam.* (Turkish Religious Affairs Foundation Publications, Istanbul) 13/523.
2. Ebû Hâmid el-Gazzâlî (d. 505/1111), *Kıyâmet ve Âhiret* (Translated by Ömer Beğ), (İstanbul: İhlas Publications, 1983).
3. Ahmed b. Muhammed el-Kastallânî (d. 923/1517), *Mevâhibu'l-Ledunniyye* (Verificated by Sâlih Ahmed eş-Şâmî, Beyrut: 1991).
4. Mevlânâ Hâlid el-Bağdâdî (ö. 1243/1827), *Herkese Lâzım Olan Îmân* (Prepared by Hüseyin Hilmi Işık), (İstanbul: Hakikat Bookstore, 148th ed. 2024).
5. Ahmed Cevdet Paşa (ö. 1313/1895), *Fâideli Bilgiler* (Prepared by Hüseyin Hilmi Işık, İstanbul: Hakikat Bookstore, 116th ed., 2024).
6. Hüseyin Hilmi Işık b. Saîd el-İstânbûlî (ö. 1422/2001), *el-İslâm ve Sâiru'l-Edyân* (İstanbul: Mektebetu'l-Hakîka, 2013).
7. Hüseyin Hilmi Işık b. Saîd el-İstânbûlî (ö. 1422/2001), *Tam İlmihâl Se'âdet-i Ebediyye*. The author first published his work in 1956 under the pseudonym M. Sıddık Gümüş. He also occasionally quotes Arvasi. Istanbul: 1956, 1984, 120th Edition, 2012. (Istanbul: Hakikat Bookstore, 2021). Hamit Algar, "Işık Hüseyin Hilmi", *Turkish Religious Affairs Foundation Encyclopedia of Islam* (Turkish Religious Affairs Foundation Publications, Revised Edition, 2020). 1/577.
8. Alî b. Emrillah-Muhammed Hâdimî, *İslâm Ahlâkı* (Prepared by Hüseyin Hilmi Işık), (İstanbul: Hakikat Bookstore, 166th ed., 2024).
9. Mevlânâ Muhammed Rebhâmî, *Riyâdu'n-Nâsihîn* (Bombay: 1895) (Translator: A. Faruk Meyan), (İstanbul: Hakikat Bookstore, 1979).
10. Ahmed Fârûk, *Ashâb-ı Kirâm* (Prepared by Hüseyin Hilmi Işık) (İstanbul: Hakikat Bookstore, 109th ed., 2024).
11. Hasan Yavaş, *Namaz Kitabı* (İstanbul: Hakikat Publications, 1998). It is the book referred to as *Kitâbu's-Salât*
12. Mevlânâ Hâlid el-Bağdâdî *el-İmân ve'l-İslâm* (İstanbul: İhlas Publication, 1980). Another Publication: (İstanbul: İhlas Publication, 2024).
13. *Encyclopedia of Islamic Scholars* (İstanbul: Türkiye Gazetesi Yayınları, 1993).

Works Whose Authors' Names He Mentioned

Hasan Yavaş has mentioned the authors and titles of some of the works he used in the writing of his book, *Guide Catechism.*

1. Imam al-Rabbani Ahmed b. Abdilehad al-Faruki al-Serhendi (d. 1033/1624), *Translation of al-Maktubat* İstanbul: Demir Bookstore, 1963) (translated by Hüseyin Hilmi Işık, Istanbul: Hakikat Kitabevi, 33rd ed. 2024). Yavaş, in the section on Belief in Angels, quotes, "Imam Rabbani, in the first volume, letter two hundred three of his book (*Mektûbât*), says..." (Yavaş, 2008, p. 40).
2. Shaykh al-Islam Ahmed Namiki Jami, *Miftah al-Najāt* (Yavaş, 2008, p. 42).
3. Prof. Carlyle, *Conference* (Yavaş, H. 2008, p. 55).
4. Beoworth Simith, *Muhammed ve Muhammed'e Bağlı Olanlar* (Yavaş, 2008, p. 55).

Verses Used as Evidence in the *Guide to Islamic Catechism*

In the "Islam and Faith" sections of his book, the Guide to Islamic Catechism, Hasan Yavaş uses verses 9-10 of Surah al-Hadid as evidence, stating, "Allah Almighty says," and citing the surah and verse numbers (Yavaş, 2008, p. 13).

In The Holy Quran, in Surah Al-i Imran, verse 31, Allah Almighty mentions the verse: "(O Beloved Prophet!) Say to them: If you love Allah, then follow me! Allah loves those who follow me and forgives their sins." (Yavaş, 2008, p. 13). For other examples where he cites surah and verse numbers, see (Yavaş, 2008, p. 85, 86, 91). He cited verses 30-33 of Surah al-Anbiya, saying, "Do the disbelievers not know that the heavens and the earth were joined together, and We separated them?" (Yavaş, 2008, p. 49). Sometimes he also cited a verse from The Holy Quran stating, "Every living thing will taste death" (Altuntaş & Şahin, 2001, p. 29/57). But he did not mention the surah or verse number where it appears (Yavaş, 2008, p. 80).

5.1. What is Religion? And why is it Necessary?

Hasan Yavaş stated that Allah Almighty says in The Holy Quran, in Surah al-Hadid, verses 9 and 10: "Do not whisper in secret meetings about committing sins, harboring enmity, or opposing the Messenger! Speak about fearing Allah! Secret meetings are what Satan desires and causes to cause distress and corruption." (Yavaş, 2008, p. 13).

5.2. How Should Belief in Angels Be?

Hasan Yavaş cited verses from the Surah al-Tahrim, verse 6, which states: "They do not disobey Allah in what he commands them, and they do what they are commanded." He also mentioned that they do not show laziness, slackness, or weariness in worship, and that the Surah al-Anbiya, verse 20, states: "They glorify Allah day and night without ceasing." (Yavaş, 2008, pp. 36–37).

5.3. Belief in the Day of Judgment

Hasan Yavaş says that resurrection after death is inevitable. Allah Almighty has not revealed to anyone when the Day of Judgment will come. Verses of the Holy Quran and hadiths confirm this. In The Holy Quran, in Surah al-A'raf, verse 86, it is stated: "O my beloved Prophet! They ask you about the Day of Judgment. Say to them: Only my Lord knows it. No one knows it. When its time comes, Allah will bring it about. It is grievous to the angels, humans, and jinn in the heavens and the earth to know the terrifying Day of Judgment. It will come upon you suddenly." And in Surah Luqman, verse 34, it is stated: "Indeed, Allah Almighty knows when the Day of Judgment will come." Yavaş interpreted the verse as follows: "However, our Prophet informed us of many signs of the Day of Judgment and their beginning. First, minor signs will appear. Then, major signs will emerge, and suddenly the Day of Judgment will come." (Yavaş, 2008, p. 52).

Yavaş cited verses from The Holy Quran, specifically verse 96 of Surah Saffat, which states, "Allah created you and created your deeds," (Yavaş, 2008, p. 98), and verse 102 of Surah An'am, which says, "There is no god but Him; He is the Creator of all things." (Yavaş, 2008, p. 99).

Hadiths Used as Evidence in the Guide Catechism

We identified and evaluated the hadith texts used by Hasan Yavaş in the "Islam and Faith" sections of his book, the *Guide Catechism*, on a section-by-section basis.

Yavaş included verses and hadiths in his explanations of the topics. While he generally mentioned the surah and verse numbers of the verses he cited as evidence, he did not mention the sources he used in the hadiths.

6.1. One Must Appreciate the Value of Youth

Hasan Yavaş, using the expression “Our beloved Prophet said,” cited the hadith: “He who says, 'I will do it tomorrow,' is doomed, he is lost” (Ahmed b. Hanbel, 1992, 1/129). But did not specify its source. Yavaş interpreted the hadith as follows: “In youth, three enemies of religion -the ego, Satan, and wicked people- try to deceive a person. In the face of these, even a small amount of worship becomes very valuable. Worship performed in old age, which is many times greater than this, does not have this much value.” (Yavaş, 2008, p. 8).

In the time of the Children of Israel, there was a young man who disobeyed Allah Almighty’s commands and committed evil deeds. He would repent, but he wouldn't abide by his repentance. Despite committing many sins, he was successful with Allah Almighty’s help because of his frequent repentance. After committing a great sin, he regretted it. He went out into the desert, rubbed his face and eyes in the dust, and said: “O my Allah Almighty! No matter how much I repented, I broke my resolve to repent. If you do not protect me from sin, I will break my repentance again and be afflicted with eternal damnation. What will become of me then?" He heard a voice saying: “O My servant! Because you have abandoned your sin, I am treating you with mercy. I have accepted your repentance and forgiven your evil deeds with My grace and generosity.” (Yavaş, 2008, p. 9). This is the anecdote that has been narrated. The meaning of the part at the end of the anecdote is that the words are addressed to Allah Almighty, and the words are addressed to the Prophet. It is a sacred hadith because it is attributed to Muhammad (p.b.u.h.). However, Yavaş did not mention the source of the hadith he quoted.

6.2. How Should Our Faith Be? What is Faith and Disbelief?

The points that Hasan Yavaş stated, "Allah Almighty conveyed His commands and prohibitions to our Beloved Muhammad (p.b.u.h.) through an angel (Gabriel), and our Prophet conveyed all of these to people."Two doctoral theses have been written on the Hadith of Gabriel. 1. Bekir Tatlı, "The Hadith of Gabriel from the Perspective of Hadith Technique and its Reflections on Islamic Thought," Ankara University Institute of Social Sciences, Unpublished Doctoral Thesis, Ankara, 2005. This thesis was published by Türkiye Diyanet Vakfı Publications in Ankara in 2015 under the title "*The Hadith of Gabriel and its Reflections on Islamic Thought*." 2. Haydar Güngör, "Gabriel in Hadiths," Ankara University Institute of Social Sciences, Unpublished Doctoral Thesis, Ankara, 2019. The thesis, "*The Conception of Gabriel in Hadith*," was published by Fecr Publications in Ankara in 2020 (1st edition) and by İlahiyat Publications in Ankara in 2024 (2nd ed.) as an e-book. Are the points mentioned in the Hadith of Gabriel? However, Yavaş did not include the sources of the hadith (Yavaş, 2008, p. 15).

Yavaş included the incident mentioned in the hadith, titled "Anecdote," as follows: “Dihya al-Kalbi (d. 50/670). Although there is insufficient information about the life of Dihya, who belonged to the Kalbi tribe and accepted Islam long before the Battle of Badr, he did not participate in that battle. Still, he took part in important battles from the Battle of Uhud onwards and commanded a military expedition (Yardım, 1994, 9/294). Came to the Messenger of Allah (p.b.u.h.) and said: ‘O Messenger of Allah! I have committed very grave sins. What is the atonement for these sins? Should my wealth and possessions be given as charity, or should I be killed?’ ‘O Dihya! What is your sin?’ ‘O Messenger of Allah! I killed my daughters in accordance with the custom of the Age of Ignorance.’ Just then, Gabriel came and said: ‘O Messenger of Allah! Allah Almighty has forgiven the sins of those who became Muslims during the Age of Ignorance.’” However, he did not mention its source (Yavaş, 2008, p. 9).

6.3 Knowing and Loving Allah Almighty

Hasan Yavaş, using the expression "Our Prophet (p.b.u.h.) says," cited the hadith: "Think about the blessings of Allah Almighty. Do not think about His essence!" (el-Muttakî, 1985, 3/106). However, he did not indicate the source of the hadit (Yavaş, 2008, p. 9).

Hasan Yavaş, using the expression "Our beloved Prophet says," (Yavaş, 2008, p. 32) cited the hadith: "The faith of one who does not love Allah and His Messenger more than anything else is not firm." (Muhammad, 1992, “Faith”, 8); Other sources of the hadith: (Muslim, 1992, pp. 75-76); (en-Nesâî, 1992, “İman”, 19, 33); (İbn Majah, 1992, “Mukaddime”, 9); (ed-Dârimî, 1992, p. 29). However, the expression "Allah" is not present in the text of the hadith. Yavaş interpreted the hadith as follows: "A servant cannot be a complete and mature believer unless he loves Allah and His Messenger more than his family, his wealth, and all creation. The place of the love of God is in the hearts. As this love increases, a person draws closer to God. He avoids everything that would distance him from Him." (Yavaş, 2008, p. 32).

Yavaş quoted the hadith Qudsi, saying, "Allah Almighty says: 'O My servants! I love you because you love Me,'" but did not specify any source where the hadith is mentioned (Yavaş, 2008, p. 33).

He quoted the sacred hadith, "Allah Almighty said to Jesus (p.b.u.h.), 'Even if you perform the worship of all creatures in heaven and on earth, it will be of no benefit unless you love My friends and distance yourself from My enemies,'" but did not specify the source of the hadith (Yavaş, 2008, p. 33).

6.5. The Duties of Angels

Hasan Yavaş cited hadiths, stating, "The most valuable of all acts of worship is to love the saints," and "The sins of one who repents and seeks forgiveness will be forgiven," (İbn Majah, 1992, “Zuhd, 30”). But did not mention their sources (Yavaş, 2008, p. 72).

Yavaş, while stating that the angels were pleased with the Prophet's (p.b.u.h.) address, cites the hadith in his work not from hadith collections, but from Imam al-Rabbani (Ahmed b. Abdilehad al-Faruqi al-Serhendi) (d. 1033/ 1624), in his work *al-Maktubat*, in the two hundred and third letter of the first volume, saying https://kitap.mollacami. com/mektubati-rabbani/konu-2117.html (Accessed May 9, 2025): "There are angels other than those who record the deeds of people. They roam the roads and street corners, searching for those who remember Allah. When they find those who remember Him, they call out to each other: 'Come here, come here!'" They say, "They are so numerous that they reach the heavens." Allah, the All-Knowing of all His servants, asks the angels, "How did you find My servants?" They reply, "O Lord! They praise and glorify You, they proclaim Your greatness, and they declare Your purity from all faults and imperfections." He asks, "Did they see me?" They reply, "No, they did not." He asks, "If they had seen Me, how would they have been?" They reply, "They would have praised You even more, glorified You even more, and proclaimed Your greatness even more." He asks, "What do they want from me?" They reply, "O Lord! They want Your Paradise." He asks, "Did they see Paradise?" They reply, "No, they did not." He asks, "If they had seen it, how would they have been?" "They would plead even more, they would ask even more. 'O Lord! These servants of Yours fear Hell. They seek refuge in You,' they would say. 'Have they seen Hell?' He would ask. 'No, they have not,' they would reply. 'If they had seen it, how would they have been?' He would ask. 'If they had seen it, they would have pleaded even more and clung even more tightly to the path of salvation,' they would reply. Allah Almighty would say to the angels, 'Bear witness that I have forgiven them all.' 'O Lord! Among those who were remembering You, so-and-so did not come to remember You. He came for worldly gain,' they would say. 'They are my guests. I am with those who

remember Me. Those who are with them will not suffer any loss, he would say," (Ahmed b. Hanbel, 1992, 2/251). He quoted the hadith (Yavaş, 2008, p. 40).

6.6. Believing in the Books

Hasan Yavaş quoted the Prophet Muhammad (p.b.u.h.) as saying (Yavaş, 2008, p. 48). "Tell your brothers in faith what you have heard from me! Convey it to one another." (al-Tirmidhi, 1992, "İlim", 13); (al-Darimî, 1992, "Mukaddime", 232). Yavaş, sometimes when quoting a saying of the Prophet (p.b.u.h.) about one of his companions, would say (Yavaş, 2008, p. 40). "He said about him: 'He was the last of the narrations. There will be no prophet after me. If there were to be a prophet after me, it would be Umar" (al-Tirmidhi, 1992, "Menâkıb", 48).

Yavaş sometimes cited hadiths within a story from the time of the Prophet (p.b.u.h.), offered interpretations of the hadiths, but did not mention their sources. "One day, as he was passing by, Umar saw the Messenger of Allah (p.b.u.h.) telling something to Abu Bakr al-Siddiq. He went to them and listened. Although others also saw them, they hesitated to come and listen. The next day, when they saw Umar, they said, 'O Umar, the Messenger of Allah was telling you something yesterday. Tell us so we can learn.' (al-Tirmidhi, 1992, "İlim", 13); (al-Dârimî, 1992, "Mukaddime", 232). Because he always said, 'Tell your brothers in faith what you have heard from me! Make them known to one another". He would say. Umar said, "Yesterday, Abu Bakr asked the Messenger of Allah about the meaning of a verse from the Quran that he couldn't understand, and the Messenger of Allah explained it to him. I listened for an hour, and I couldn't understand anything I heard." This was because the explanation was given in terms of Abu Bakr's high level of understanding. Umar was so high in rank that the Messenger of Allah (p.b.u.h.) said about him: "I am the last of the prophets. No prophet will come after me. If a prophet were to come after me, Umar would be that prophet." (Yusuf, 3/2000). Despite his high rank and excellent knowledge of Arabic, he couldn't even understand the Quran's interpretation. This is because the Messenger of Allah explained to everyone according to their level of understanding. Abu Bakr's rank was far higher than his. However, even Gabriel (p.b.u.h.) couldn't understand the meaning and secrets of the Quran. He would ask the Messenger of Allah (peace and blessings be upon him). Only Muhammad (p.b.u.h.) understood the meaning of the Holy Quran and conveyed it through his noble hadiths. He is the one who interprets the Holy Quran. And the true book of interpretation is his noble hadiths…" (Yavaş, 2008, pp. 48–49).

6.7. Believing in Prophets

Hasan Yavaş stated, "Prophets are alive in their graves with a life we do not know. The earth does not decay their blessed bodies. That is why it is said in the hadith: 'Prophets pray and perform Hajj in their graves.'" (al-Bayhaqi, A. n. d., p. 74). He cited this hadith as evidence (Yavaş, 2008, pp. 56–57). Yavaş, after defining "discernment" as "extraordinary things that occur when one is a righteous and pious true Muslim," cited the following hadith as evidence (Yavaş, 2008, p. 48).: "Beware of the discernment of the believer! For he sees with the light of Allah." (al-Tirmidhi, 1992, "Tefsir", 16). Yavaş cited the following hadith as evidence regarding the virtues of the four caliphs: "The most merciful of my Ummah is Abu Bakr. The most strict in fulfilling the commands of Allah is Umar. The most modest is Uthman. The one who most resolved difficulties in religion is Ali..." (İbn Majah, 1992, "Mukaddime, 11"). But did not mention its source. (Yavaş, 2008, p. 74).

Yavaş cited three hadith evidence that loving religious figures stems from loving the Prophet:
1. "Whoever loves them, loves them because he loves me. Whoever is hostile to them is hostile to me." (al-Tirmidhi, 1992, "Menakıb, 59).
2. "Whoever loves my companions, loves them because he loves me. Whoever does not love them does not love me. Whoever offends them, offends me. And whoever offends me, offends Allah. And whoever offends Allah will certainly be punished." (al-Tirmidhi, 1992, "Menakıb, 59).

3. “If Allah wishes to do good to a servant from my ummah, he places the love of my companions in his heart. He loves them all as if they were his own life.” However, he did not mention their sources. (Yavaş, 2008, p. 74).

6.8. Belief in the Day of Judgment

Hasan Yavaş cited a hadith as evidence, stating (Yavaş, 2008, p. 80). "The grave is the first of the stages of the Hereafter. For those who escape it, passing through the subsequent stages will be easy. For those who cannot escape the grave, the subsequent stages will be more difficult, and the torments more severe." (al-Tirmidhi, 1992, “Zuhd, 5”). Yavaş, using the expression, "Our beloved Prophet says," cited the hadith, "The grave is either a garden from the gardens of Paradise or a pit from the pits of Hell," (al-Tirmidhi, 1992, “Sıfat al-Kıyame, 26”) and offered the following interpretation: "He informed us that in the grave, those who believe and are without fault in their worship will be rewarded with goodness and blessings, while those who disbelieve and sinful Muslims will be punished. The punishment in the grave is real. Those who urinate on themselves, and Muslims who quarrel with each other, will face punishment in the grave." (Yavaş, 2008, p. 80).

Yavaş, using the phrase "Our beloved Prophet said," stated: "The Day of Judgment will not come until ten great signs are seen." (Muslim, 1992, “Fiten, 13”). Following this, he quoted a hadith: "It is stated in the Hadith: 'Fire, the Antichrist, the Beast of the Earth, the sun rising from the west, the descent of Jesus from heaven, the emergence of Gog and Magog, lunar eclipses in the east, west, and Arabia, and after these, a fire will emerge from Yemen and gather the people together." (Muslim, 1992, “Fiten, 13”). He thus listed these signs but did not provide a source for the hadith (Yavaş, 2008, p. 80). Yavaş pointed out that one of the significant signs of the Day of Judgment is the coming of the Mahdi, and cited a hadith as evidence (Yavaş, 2008, p. 83): “Before the Day of Judgment, Allah Almighty will create one of my descendants whose name will be like my name and whose father's name will be like my father's name, and he will fill the world with justice. Before him, the world will be filled with oppression, but in his time, the world will be filled with justice.” (Abu Dawud, 1992, “Mehdi, 1”).

Yavaş cited a hadith as evidence (Yavaş, 2008, p. 80). for the seven classes of people who will be rewarded under the shade of Allah's Throne on the Day of Judgment: "Allah will shade seven classes of people under the shade of His Throne, for on that day there will be no other shade: 1. Rulers and governors who govern with justice; 2. Young people who worship; 3. Those whose hearts are attached to mosques (those who observe prayer and congregational worship); 4. Two believers who love each other for the sake of Allah, and who remain in that love when they come together and when they part; 5. Those who, when a beautiful woman calls them to do something shameful, fear Allah and say, 'I cannot do this, I fear Allah'; 6. Those who do not show off when giving charity (meaning that their left hand should not know what their right hand has given); 7. Those who shed tears when they say 'Allah." (al-Bukhari, 1992, “Ezan, 36”). Yavaş, citing the hadith, "Our beloved Prophet said: 'I will intercede before everyone else, and my intercession will be accepted before everyone else,'" cited it as evidence and interpreted it as follows: (Yavaş, 2008, p. 87). "In the Hereafter, prophets, saints, righteous people, angels, and those whom Allah Almighty permits will intercede, and their intercessions will be accepted." (Abu Dawud, 1992, “Sünnet, 14”).

Yavaş, using the phrase "Our beloved Prophet said," cited a hadith as evidence for five things everyone will be questioned about (Yavaş, 2008, p. 89): "On the Day of Judgment, everyone will be questioned about five things: 1. Where did they spend their life? 2. What did they do in their youth? 3. Where did they earn their wealth? 4. Where did they spend their wealth? 5. Did they act upon the knowledge they acquired? (Tirmidhi, “Sıfat al-Kıyâme”, 1).

Yavaş, regarding the Pool of Kawthar, quoted the hadith: “Its size is like a month's journey. Its water is whiter than milk, and its scent is more beautiful than musk. The cups around it are more numerous than the stars. Whoever drinks from it once will never be thirsty again (al-Bukhari, 1992, “Rikak, 53”) (even in Hell). The addition of "even if in Hell" is Yavaş's interpretation. It is not present in the text of the hadith (Yavaş, 2008, p. 87). However, he did not specify the source. Using the expression, “Our Prophet (p.b.u.h.) said,” he continued: “I will arrive at the pool before you and wait for you there. Whoever comes to my pool and drinks from it will never be thirsty again. Whoever is not thirsty will enter Paradise” (Muslim, “Fedâil, 9”). My pool has four pillars. One is under the supervision of Abu Bakr, the second under the control of Umar, the third under his watchful eye, and the fourth under the supervision of Ali. Abu Bakr will not give water from the pool to those who love Abu Bakr and hate Umar. Umar will not give water to those who love Umar and do not love Abu Bakr.” Osman would not give a drop of water to one who loves Osman and hates Ali. Ali would not give a drop of water to one who loves Ali and hates Osman. One whose belief in Abu Bakr is reasonable will have the righteous religion. One who has a correct belief in Umar will have revealed the path of Islam. The light of Allah will illuminate one who has faith in Osman. One who has a reasonable belief in Ali will have grasped the firm rope and entered the great and main path. All of my companions are sincere believers with reasonable beliefs. Whoever speaks ill of them is a hypocrite.” This hadith was cited as evidence (Yavaş, 2008, p. 90). We could not find any source for this hadith.

6.9. Belief in Divine Decree and Fate

Hasan Yavaş, quoting the hadith, "Our beloved Prophet said: 'The foundation and strongest sign of faith is to love Muslims and not to love those who are hostile to Muslims." (Abu Dawud, 1992, “Sünnet, 3”). Yavaş cited the hadith of our beloved Prophet as evidence, but did not specify its source. (Yavaş, 2008, p. 104). The hadith states: "When a servant sins, a black spot appears in his heart; if he repents, his heart is cleansed. If he commits many sins and continues to sin, the blackness in his heart increases, and the whole heart becomes dark." (İbn Majah, 1992, “Zuhd, 29”).

Analysis

Hasan Yavas is a retired mufti from the Presidency of Religious Affairs. Yavaş, who wrote 548 columns and 5 books. He currently writes columns for the Türkiye Newspaper and the website, and produces Ramadan programs for TGRT. Yavas has written five works: "*Catechism for Everyone*", "*Prayer Book*", "*Guide Catechism*," "Guide for Women," and "*Great Women of Islam and a Guide for Young People*." He has compiled his *Guide Catechism* in ten chapters. We conducted our research on the following topics: "Advice for young people," "How to be a good Muslim?" in the introduction. "Youth should be appreciated," he addresses in the first chapter, "Islam, the beautiful religion," and "What should our faith be like?" in the second. Yavas, books whose names and authors are specified at the end of his book named *Guide Catechism* used as a source the following books: Abu Hamid el-Ghazzali’s (d. 505/1111), *Kimyay-ı Saadet*, Doomsday and the Hereafter, al-Kastallani’s (d. 923/1517), *Mawahib al-Ladunniyye*, Mevlana Khalid el-Baghdadi’s (d. 1243/1827), Everyone Needs Iman, Ahmed Cevdet Pasha’s (d. 1313/1895), *Beneficial Knowledge*, Hüseyin Hilmi Işık’s (d. 1422/2001), *el-İslam and The Others Religion and Complete Catechism Saadet al-Abadiya*, Hadimi’s, *Islamic Ethics*, Rebhami’s, Riyad an-Nasihin Ahmed Faruk’s, *Ashab al-Kiram’s own Prayer Book*, *al-Iman wa’l-Islam* whose author we could not identify and the *Encyclopedia of Islamic Scholars* published by Türkiye Newspaper however he did not mention which volumes or pages of these books he quoted.

The sources Yavas cites as sources in his *Guide Catechism* are İmam al-Rabbani al-Sarhandi’s (d. 1033/1624), *The Translation of Letters*, Şeyh al-İslam Ahmed Namıki Jami’s*, Miftah al-Nacat*, Prof. Carlyle’s *Conference*, and Beoworth Smith’s *Mohammed and Those Devoted to Mohammed.* Although Yavaş cites these sources and their authors, he does not specify which pages of these books

the quotations appear on. Hasan Yavaş's work, *Guide Catechism*, appeals to a wide audience because it addresses issues of faith, worship, conduct, and morality. Despite its numerous editions, both domestically and internationally, the lack of any book, article, or paper addressing the *Guide Catechism* paved the way for this research. When mentioning verses, Yavaş included the number of surahs and verses with the condition "Allah Almighty says", while in mentioning hadiths, Yavas used the conditions "Our beloved Prophet said", "The Prophet Muhammad said", "Our Prophet Muhammad said", "It was declared in a hadith" and "Our beloved Prophet reported as follows" using a hadith or a sacred hadith within a legend as a form of istishhad. Yavas did not confine himself to simply making evidence (istishhads) from verses and hadiths in his explanations; he also occasionally quoted legends, poems, and aphorisms. In his work, *Guide Catechism* Yavas attempts to explain the fundamental principles of faith and the foundations of worship in a simple language. Our research examines Hasan Yavas's life and works, as well as the "Islam and Faith" section of the *Guide Catechism*. The factor that motivated Yavas to write Guide Catechism is the fundamental principle mentioned in the Quran and hadith: "al-emri bi al-maruf va al-nehyi al-munkar" (enjoining what is right and forbidding what is wrong).

The hadiths that Yavas cites as sources in the Islam and Faith sections of his *Guide Catechism* book are generally in the *al-Jami's-Sahih of Muhammad İbn Ismail al-Bukhari* (d. 256/870) who is famous with the name *al-Kutub al-Sitta*, in the *al-Jami's-Sahih of Muslim ibn al-Hajjaj* (d. 261/874), in the al-Jami's-Sahih of Ibn Majah Abu Abdullah Muhammad ibn Yazid (d. 273/886), in the *al-Sunan of Abu Dawud Suleyman ibn al-Ash'as* (d. 275/888), in the *al-Sunan of Muhammad ibn İsa al-Tirmidhi* (d. 279/892) and in the *al-Musnad of Ahmad ibn Hanbal* (d. 242/855) which is included in the *as-Sunan of Abdullah ibn Abdirrahman al-Darimi* (d. 255/ 869) apart from *al-Kutub al-Sitta*. Although Hasan Yavas quoted from these works in his explanations of the topics, he did not cite their sources. Hasan Yavaş's work, "Guide Catechism," serves as the basis for the Faith and Islam sections of our research. This work, a guide to Islamic catechism, is not an academic study but rather a public awareness-raising effort. Yavaş has provided sufficient information regarding the context of the hadith narrations he cited in his "Guide Catechism"; however, while he has included some source names from the main sources of hadith, such as al-Bukhari, Muslim, Abu Dawud, al-Tirmidhi, and al-Nasai, he has been insufficient in specifying which sections and pages of those sources the hadith narrations are located in.

The fact that Hasan Yavaş's, "*Guide Catechism*, work is insufficient in citing the sources of the hadiths he presents in the chapters on faith and Islam has not diminished its popularity; indeed, as we mentioned in the section on the author's works, the book has gone through many editions. In our research, we have avoided general assessments of the sections on Faith and Islam in Hasan Yavaş's "*Guide Catechism*", and instead reached conclusions through concrete examples, making our article an original work in this respect. We believe our study will also serve as a foundation for future similar studies. Our research will provide readers of Hasan Yavaş's work with a scholarly perspective and contribute to their understanding of its shortcomings. We have identified the sources of these hadiths. He also occasionally provided brief commentaries on the hadiths he cited.

Conclusion

Hasan Yavaş is an author who writes on Islamic topics. His books have gone through numerous printings. The work chosen for our research, called Guide Catechism, is one of them. His works generally cover topics related to worship, ethics, and social conduct. In his work titled "*Guide Catechism,"* Yavaş includes verses from The Holy Quran in his explanations, stating "Allah Almighty says," and indicating the surah and verse numbers in which they appear. In Yavaş's work, "*Guide Catechism*," while using the Prophet's (p.b.u.h.) hadiths as a source, he employs expressions such as "Our beloved Prophet said," "Our Master, the Messenger of Allah (p.b.u.h.), says," and "It is stated in the Hadith." He also cites qudsi hadiths as sources, using expressions such as "Allah Almighty

says" and "Allah said," but he does not indicate the sources of the hadiths. He quotes a hadith from the work "*al-Maktubat*" by Imam al-Rabbani Ahmed b. Abdilehad al-Faruki al-Serhendi (d. 1033/ 1624), but he does not indicate which hadith book he quoted. Yavaş included poems and anecdotes related to the subject in his book, *Guide Catechism*, and sometimes incorporated a sacred hadith within an anecdote, but he did not specify the sources from which he quoted the poems, anecdotes, and sacred hadiths he cited. We believe that Yavaş, while writing his book titled "*Guide Catechism*", was more concerned with making the work easily understandable than with listing the sources he used, and that the quotations he made from verses of The Holy Quran and hadiths were aimed at this goal. Yavaş's book, "*Guide Catechism*", is not so much a work that addresses issues in scholarly methods and aims, but rather one that is supported by Quranic verses and hadiths at a level understandable to the general public. We hope that the research we have conducted will serve as a resource for future studies on this subject.

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Rəqəmsal transformasiya: dayanıqlı iqtisadi inkişaf və idarəetmə sistemində süni intellektin rolu

Zemfira Əliyeva[1], Ülviyyə Aşurova[1*], Xanım Göyüşova[2], Cəfər Cəfərli[1], Xəlil Əliyev[1]

Xülasə. *Bu məqalədə rəqəmsal transformasiya proseslərində süni intellektin (AI) rolu və onun dayanıqlı iqtisadi inkişaf və idarəetmə sistemlərinə təsiri kompleks şəkildə təhlil edilir. Tədqiqatın əsas məqsədi AI texnologiyalarının iqtisadi səmərəlilik, innovasiya potensialı və institusional idarəetmə mexanizmləri ilə qarşılıqlı əlaqəsini müəyyənləşdirmək və bu əlaqələr əsasında inteqrativ konseptual çərçivə formalaşdırmaqdır. Məqalə 2019–2026-cı illəri əhatə edən sistemli ədəbiyyat icmalı və konseptual modelləşdirmə metodlarına əsaslanır. Araşdırma nəticələri göstərir ki, süni intellekt rəqəmsal transformasiyanın əsas hərəkətverici qüvvəsi kimi çıxış edərək iqtisadi sistemlərdə məhsuldarlığın artmasına, resursların daha səmərəli idarə olunmasına və innovativ biznes modellərinin formalaşmasına şərait yaradır. Eyni zamanda AI texnologiyaları idarəetmə sistemlərində qərarvermə proseslərini optimallaşdırır, məlumat əsaslı siyasətlərin hazırlanmasını sürətləndirir və ictimai xidmətlərin keyfiyyətini artırır. Bu xüsusiyyətlər AI-nin dayanıqlı inkişaf məqsədlərinə (SDG) nail olunmasında mühüm rol oynadığını göstərir. Bununla yanaşı, tədqiqat süni intellektin tətbiqi ilə bağlı mövcud riskləri də müəyyən edir. Bu risklərə alqoritmik qərəz, məlumatların məxfiliyi, rəqəmsal bərabərsizlik və yüksək enerji istehlakı kimi problemlər daxildir. Məqalədə bu problemlərin aradan qaldırılması üçün etik prinsiplərə əsaslanan və şəffaflıq, hesabatlılıq, adaptivlik və inteqrasiya kimi komponentləri özündə birləşdirən AEIAT əsaslı idarəetmə modelinin tətbiqi təklif olunur. Nəticə etibarilə, süni intellekt yalnız texnoloji alət deyil, həm də iqtisadi və institusional transformasiyanın strateji elementi kimi çıxış edir. Onun effektiv və məsuliyyətli tətbiqi dayanıqlı iqtisadi inkişafın təmin olunması və müasir idarəetmə sistemlərinin formalaşdırılması baxımından mühüm əhəmiyyət kəsb edir.*

Açar sözlər: *süni intellekt, rəqəmsal transformasiya, dayanıqlı inkişaf, idarəetmə, rəqəmsal iqtisadiyyat*

[1]Mingəçevir Dövlət Universiteti, Mingəçevir, Azərbaycan
[2]Mingəçevir Turizm Kolleci, Mingəçevir, Azərbaycan
[*]Məsul müəllif. E-poçt: ulviyya.ashurova@mdu.edu.az
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Digital Transformation: The Role of Artificial Intelligence in Sustainable Economic Development and Governance

Zemfira Aliyeva[1], Ulviyya Ashurova[1*], Khanim Goyushova[2], Jafar Jafarli[1], Khalil Aliyev[1]

Abstract. *This article provides a comprehensive analysis of the role of artificial intelligence (AI) in digital transformation processes and its impact on sustainable economic development and governance systems. The main objective of the study is to identify the interaction of AI technologies with economic efficiency, innovation potential, and institutional governance mechanisms, and to formulate an integrative conceptual framework based on these relationships. The article is based on systematic literature review and conceptual modeling methods covering the period from 2019 to 2026. Research findings indicate that artificial intelligence serves as a key driver of digital transformation, fostering increased productivity, more efficient resource management, and the emergence of innovative business models in economic systems (Westover, 2025; Nature Sustainability, 2025). At the same time, AI technologies optimize decision-making processes in management systems, accelerate the development of data-driven policies, and enhance the quality of public services (Bokhari et al., 2025). These features indicate that AI plays a crucial role in achieving the Sustainable Development Goals (SDGs). Additionally, the study identifies existing risks associated with the application of artificial intelligence. These risks include issues such as algorithmic bias, data privacy, digital inequality, and high energy consumption. The article proposes the implementation of an AEIAT-based governance model to address these problems, one that is based on ethical principles and incorporates components such as transparency, accountability, adaptability, and integration. In conclusion, artificial intelligence serves not just as a technological tool, but also as a strategic element of economic and institutional transformation. Its effective and responsible application is crucial for ensuring sustainable economic development and shaping modern management systems.*

Keywords: *artificial intelligence, digital transformation, sustainable development, governance, digital economy*

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[1]Mingachevir State University, Mingachevir, Azerbaijan
[2]Mingachevir Tourism College, Mingachevir, Azerbaijan
[*]Corresponding author. E-mail: ulviyya.ashurova@mdu.edu.az
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Giriş

XXI əsrdə qlobal iqtisadiyyat və idarəetmə sistemləri dərin struktur dəyişiklikləri ilə xarakterizə olunur və bu dəyişikliklərin mərkəzində rəqəmsal transformasiya dayanır(Atieh et al., 2026). Rəqəmsal transformasiya yalnız informasiya texnologiyalarının tətbiqi ilə məhdudlaşmır, o, eyni zamanda iqtisadi fəaliyyətin təşkili, idarəetmə mexanizmləri və qərarvermə proseslərinin fundamental şəkildə yenidən qurulmasını əhatə edir. Bu kontekstdə süni intellekt (AI) texnologiyaları – xüsusilə maşın öyrənməsi, dərin öyrənmə və böyük verilənlərin analizi – transformasiyanın əsas hərəkətverici qüvvəsinə çevrilmişdir (Yue et al., 2026).

Müasir tədqiqatlar göstərir ki, süni intellekt iqtisadi sistemlərdə məhsuldarlığın artırılması, əməliyyat xərclərinin azaldılması və innovasiya proseslərinin sürətləndirilməsi baxımından strateji rol oynayır (OECD, 2025). Eyni zamanda, AI əsaslı sistemlər böyük həcmli məlumatların real vaxt rejimində

təhlilini mümkün edərək daha dəqiq və əsaslandırılmış qərarların qəbulunu təmin edir. Bu isə xüsusilə dövlət idarəçiliyi və korporativ idarəetmə sistemlərində şəffaflığın və effektivliyin artırılmasına gətirib çıxarır. Digər tərəfdən, qlobal səviyyədə qəbul edilmiş Dayanıqlı İnkişaf Məqsədləri (SDGs) iqtisadi artımın yalnız kəmiyyət deyil, həm də keyfiyyət aspektlərini ön plana çəkir. Bu məqsədlərə nail olmaq üçün resursların səmərəli istifadəsi, ekoloji balansın qorunması və sosial inklüzivliyin təmin olunması zəruridir. Məhz bu nöqtədə süni intellekt texnologiyaları dayanıqlı inkişafın təmin edilməsində mühüm alət kimi çıxış edir. AI vasitəsilə enerji istehlakının optimallaşdırılması, iqlim dəyişikliklərinin proqnozlaşdırılması və sosial xidmətlərin daha effektiv təşkili mümkün olur.

Bununla belə, süni intellektin geniş tətbiqi bir sıra yeni çağırışlar da yaradır. Alqoritmik qərəz, məlumatların məxfiliyi, rəqəmsal bərabərsizlik və texnoloji asılılıq kimi problemlər həm iqtisadi, həm də sosial baxımdan ciddi risklər yaradır. Xüsusilə inkişaf etməkdə olan ölkələrdə rəqəmsal infrastrukturun qeyri-bərabər inkişafı AI texnologiyalarından istifadədə fərqliliklərə səbəb olur və bu da qlobal miqyasda inkişaf fərqlərini dərinləşdirə bilər. Mövcud elmi ədəbiyyatın təhlili göstərir ki, süni intellekt, rəqəmsal transformasiya və dayanıqlı inkişaf arasında əlaqələr geniş şəkildə araşdırılsa da, bu üç komponentin vahid konseptual çərçivədə inteqrasiyası hələ də kifayət qədər işlənməmişdir. Əksər tədqiqatlar ya texnoloji aspektlərə, ya da dayanıqlılıq məsələlərinə fokuslanır, lakin onların idarəetmə sistemləri ilə qarşılıqlı əlaqəsi sistemli şəkildə təhlil edilmir.

Bu baxımdan, təqdim olunan məqalənin əsas məqsədi süni intellektin rəqəmsal transformasiya vasitəsilə dayanıqlı iqtisadi inkişaf və idarəetmə sistemlərinə təsirini kompleks şəkildə araşdırmaq və bu əlaqələri izah edən inteqrativ nəzəri model təklif etməkdir.

Məqalə aşağıdakı tədqiqat suallarına cavab axtarır:
- Süni intellekt iqtisadi inkişaf və məhsuldarlıq göstəricilərinə necə təsir edir?
- AI əsaslı texnologiyalar idarəetmə sistemlərini necə transformasiya edir?
- Süni intellekt dayanıqlı inkişaf məqsədlərinə nail olunmasına hansı mexanizmlərlə töhfə verir?
- Bu prosesdə yaranan risklər hansılardır və onların idarə olunması necə mümkündür?

Beləliklə, bu tədqiqat süni intellektin yalnız texnoloji innovasiya kimi deyil, həm də iqtisadi və institusional transformasiyanın əsas elementi kimi çıxış etdiyini əsaslandırır və bu sahədə mövcud elmi boşluqların aradan qaldırılmasına töhfə verməyi hədəfləyir.

Rəqəmsal transformasiya və dayanıqlı iqtisadi inkişafın nəzəri əsasları

Rəqəmsal transformasiya və dayanıqlı iqtisadi inkişaf müasir iqtisadi nəzəriyyədə qarşılıqlı əlaqəli və bir-birini tamamlayan iki əsas konsepsiya kimi çıxış edir. Bu anlayışların nəzəri əsaslarının təhlili göstərir ki, texnoloji tərəqqi ilə dayanıqlılıq arasında əlaqə təkcə iqtisadi artım deyil, həm də sosial rifah və ekoloji balans kontekstində formalaşır. Rəqəmsal transformasiya klassik texnoloji modernizasiya anlayışından fərqli olaraq daha geniş məzmun daşıyır və iqtisadi sistemlərin struktur dəyişikliklərini əhatə edir.

Bu proses bir neçə əsas nəzəri yanaşma ilə izah olunur:
a) texnoloji determinizm yanaşması
Bu yanaşmaya görə texnologiya iqtisadi və sosial dəyişikliklərin əsas hərəkətverici qüvvəsidir. Süni intellekt, böyük verilənlər və bulud texnologiyaları iqtisadi sistemlərin fəaliyyət mexanizmini köklü şəkildə dəyişir.
b) sumpeterin innovasiya nəzəriyyəsi
J. Schumpeter-in "yaradıcı dağıntı" konsepsiyasına əsasən, innovasiyalar köhnə iqtisadi strukturları dağıdaraq yeni və daha səmərəli sistemlər yaradır. Rəqəmsal transformasiya bu prosesin müasir təzahürüdür və AI bu transformasiyanın əsas alətlərindən biridir (Schumpeter, 1942; Chouman, 2025).

c) rəqəmsal iqtisadiyyat nəzəriyyəsi
Bu yanaşma iqtisadi fəaliyyətin rəqəmsal platformalar üzərindən həyata keçirildiyini vurğulayır.

Burada məlumat əsas resurs kimi çıxış edir və AI bu resursun dəyərə çevrilməsini təmin edir.
Dayanıqlı inkişaf konsepsiyası ilk dəfə World Commission on Environment and Development tərəfindən irəli sürülmüş və iqtisadi inkişafın gələcək nəsillərin ehtiyaclarını riskə atmadan təmin olunmasını nəzərdə tutur.

Bu konsepsiya üç əsas sütun üzərində qurulur:
1. İqtisadi dayanıqlılıq
- uzunmüddətli iqtisadi artım
- resursların effektiv istifadəsi
- innovasiya və rəqabət qabiliyyəti

2. Sosial dayanıqlılıq
- sosial bərabərlik
- təhsil və insan kapitalının inkişafı
- inklüziv iqtisadi sistem

3. Ekoloji dayanıqlılıq
- təbii resursların qorunması
- karbon emissiyalarının azaldılması
- yaşıl iqtisadiyyatın təşviqi

Bu yanaşma hazırda United Nations tərəfindən qəbul edilmiş Dayanıqlı İnkişaf Məqsədləri (SDGs) çərçivəsində daha da inkişaf etdirilmişdir (United Nations, 2015; Gafsi et al., 2026).

Rəqəmsal transformasiya ilə dayanıqlı inkişafın inteqrasiyası

Rəqəmsal transformasiya dayanıqlı inkişafın təmin olunmasında katalizator rolunu oynayır (Atieh et al., 2026; Gafsi et al., 2026; Nature Sustainability, 2025).

Bu inteqrasiya aşağıdakı nəzəri mexanizmlərlə izah olunur:
a) effektivlik və optimallaşdırma nəzəriyyəsi
AI və rəqəmsal texnologiyalar resursların istifadəsini optimallaşdırır. Bu, həm iqtisadi səmərəliliyi artırır, həm də ekoloji yükü azaldır (Westover, 2025; Bokhari et al., 2025).
b) məlumat əsaslı iqtisadiyyat modeli (Data-driven economy)
Məlumat yeni "istehsal faktoru" kimi çıxış edir. AI bu məlumatların analizini təmin edərək daha effektiv qərarverməyə imkan yaradır (OECD, 2025; Yue et al., 2026; ScienceDirect, 2025).
c) innovasiya ekosistemi yanaşması
Rəqəmsal transformasiya innovasiya ekosistemlərini genişləndirir və dövlət–biznes–akademiya əməkdaşlığını gücləndirir (Chouman, 2025; Kapartziani, 2025).

Metodlar

Süni intellektin nəzəri rolu

Süni intellekt bu iki konsepsiyanı birləşdirən əsas texnoloji platformadır. Onun rolu aşağıdakı nəzəri funksiyalarla izah olunur:

- transformativ funksiya – iqtisadi və idarəetmə strukturlarını dəyişir
- inteqrativ funksiya – müxtəlif sektorları vahid rəqəmsal sistemdə birləşdirir
- proqnostik funksiya – gələcək riskləri və trendləri müəyyən edir

AI-nin bu xüsusiyyətləri onu dayanıqlı inkişafın təmin olunmasında strateji alətə çevirir.

Konseptual inteqrasiya modeli

Rəqəmsal transformasiya və dayanıqlı inkişafın qarşılıqlı əlaqəsini aşağıdakı kimi ümumiləşdirmək olar:
- Giriş (Input): texnologiya, məlumat, insan kapitalı
- Proses (Process): AI əsaslı analiz və qərarvermə
- Çıxış (Output): iqtisadi artım, sosial rifah, ekoloji balans

Bu model göstərir ki, AI yalnız vasitə deyil, həm də sistemin mərkəzi elementi kimi çıxış edir.

Bununla yanaşı, nəzəri çərçivə bəzi məhdudiyyətləri də üzə çıxarır (OEGD, 2025; SchienceDirect, 2025):
- texnologiyanın qeyri-bərabər yayılması
- rəqəmsal uçurum (digital divide)
- ekoloji xərclərin artması (data mərkəzləri və enerji istehlakı)

Bu problemlər göstərir ki, rəqəmsal transformasiya avtomatik olaraq dayanıqlılıq yaratmır və düzgün idarəetmə mexanizmləri tələb olunur (Chouman, 2025).

Beləliklə, nəzəri təhlil göstərir ki, rəqəmsal transformasiya və dayanıqlı iqtisadi inkişaf qarşılıqlı asılı sistemlərdir və bu sistemlərin kəsişmə nöqtəsində süni intellekt dayanır. AI texnologiyalarının effektiv tətbiqi bu iki istiqamətin sinerji yaratmasına imkan verir və müasir iqtisadi inkişaf modelinin əsasını təşkil edir.

Süni intellekt (AI) müasir iqtisadi sistemlərdə struktur dəyişikliklər yaradan və iqtisadi inkişafın keyfiyyətini yeni mərhələyə daşıyan əsas texnoloji amillərdən biridir. Əgər əvvəlki sənaye inqilablarında əsas rol fiziki kapital və əmək oynayırdısa, hazırda məlumat, alqoritmlər və hesablama gücü iqtisadi artımın əsas determinantlarına çevrilmişdir. Bu baxımdan AI iqtisadi inkişafın həm sürətini, həm də strukturunu dəyişdirən transformativ faktor kimi çıxış edir. Süni intellekt iqtisadi inkişafın əsas göstəricilərindən biri olan məhsuldarlığa birbaşa təsir göstərir (Westover, 2025; OECD, 2025; Atieh et al., 2026).

AI texnologiyaları:
- istehsal proseslərini avtomatlaşdırır
- əməliyyat xərclərini azaldır
- səhvləri minimuma endirir
- prosesləri optimallaşdırır (Bokhari et al., 2025; Gafsi et al., 2026)

Bu təsir makroiqtisadi səviyyədə ümumi daxili məhsulun (ÜDM) artımına səbəb olur (OECD, 2025; Nature Sustainability, 2025).

AI-nin iqtisadi artıma təsiri çox vaxt genişləndirilmiş istehsal funksiyası ilə izah olunur (Westover, 2025):

$$Y=A\cdot f\,(K, L, AI)\ Y$$

Burada:
- Y – iqtisadi məhsul (ÜDM)
- K – kapital
- L – əmək
- AI – texnoloji/alqoritmik kapital
- A – ümumi məhsuldarlıq səviyyəsi

Bu model göstərir ki, AI artıq ayrıca istehsal faktoru kimi çıxış edir və ənənəvi kapital–əmək modelini genişləndirir (Atieh et al., 2026; Yue et al., 2026).

Süni intellekt innovasiya proseslərinin həm sürətini, həm də miqyasını artırır (Kapartziani, 2025; Nature Sustainability, 2025).

AI aşağıdakı yollarla innovasiyanı təşviq edir:
- yeni məhsul və xidmətlərin yaradılması
- tədqiqat və inkişaf (R&D) proseslərinin avtomatlaşdırılması
- məlumat əsaslı qərarvermə
- eksperimental modellərin sürətli sınağı (Chouman, 2025; ScienceDirect, 2025)

Bu proseslər nəticəsində "AI-driven innovation" anlayışı formalaşır. Xüsusilə farmasevtika, maliyyə texnologiyaları (fintech), logistika və enerji sektorlarında AI innovasiyanın əsas generatoruna çevrilmişdir (Bokhari et al., 2025; Gafsi et al., 2026).

Süni intellekt əmək bazarına ikitərəfli təsir göstərir:

Müsbət təsirlər:
- yeni peşələrin yaranması (data scientist, AI engineer və s.)
- yüksək ixtisaslı əmək tələbinin artması
- əmək məhsuldarlığının yüksəlməsi

Mənfi təsirlər:
- aşağı ixtisaslı işlərin avtomatlaşdırılması
- texnoloji işsizlik riski
- gəlir bərabərsizliyinin artması (OECD, 2025; ScienceDirect, 2025)

Bu proses iqtisadi nəzəriyyədə "skill-biased technological change" kimi izah olunur. Yəni AI əsasən yüksək bacarıqlı işçi qüvvəsinə üstünlük verir.

AI iqtisadi sistemlərdə resursların optimallaşdırılmasını təmin edir. Bu xüsusilə aşağıdakı sahələrdə özünü göstərir:
- enerji sektoru: ağıllı şəbəkələr və enerji istehlakının optimallaşdırılması
- kənd təsərrüfatı: dəqiq əkinçilik (precision agriculture)
- sənaye: ağıllı istehsal (Industry 4.0)

Bu yanaşma həm iqtisadi səmərəliliyi artırır, həm də ekoloji dayanıqlılığı dəstəkləyir.

Rəqəmsal iqtisadiyyatın formalaşması

Süni intellekt rəqəmsal iqtisadiyyatın əsasını təşkil edir. Bu iqtisadi model aşağıdakı xüsusiyyətlərlə fərqlənir:

- platform iqtisadiyyatı (platform economy)
- məlumat əsaslı dəyər yaradılması
- şəbəkə effektləri (network effects)
- qlobal miqyasda fəaliyyət

AI bu sistemdə məlumatları emal edərək onları iqtisadi dəyərə çevirir. Beləliklə, məlumat yeni "neft" kimi qəbul olunur və AI onun "emal zavodu" rolunu oynayır.

Süni intellekt maliyyə sektorunda da ciddi transformasiyaya səbəb olmuşdur:

- risklərin qiymətləndirilməsi (credit scoring)
- alqoritmik ticarət (algorithmic trading)
- fraud detection sistemləri
- fərdiləşdirilmiş bank xidmətləri

Bu dəyişikliklər maliyyə bazarlarının daha şəffaf və effektiv fəaliyyət göstərməsinə imkan yaradır.

AI dövlətlər arasında iqtisadi rəqabətin yeni mərhələsini formalaşdırır (Atieh et al., 2026; OECD, 2025). Texnoloji liderlik artıq iqtisadi gücün əsas göstəricilərindən biridir.

Bu baxımdan:

- AI-yə investisiya edən ölkələr daha sürətli inkişaf edir
- texnoloji asılılıq yeni iqtisadi risklər yaradır
- rəqəmsal suverenlik anlayışı ön plana çıxır

Tənqidi yanaşma və məhdudiyyətlər

Süni intellektin iqtisadi inkişafda rolu müsbət olmaqla yanaşı, bəzi riskləri də ehtiva edir:
- rəqəmsal bərabərsizlik: texnologiyaya çıxış fərqləri
- monopoliyalaşma: böyük texnologiya şirkətlərinin üstünlüyü
- ekoloji xərclər: yüksək enerji istehlakı
- etik problemlər: alqoritmik qərəz

Bu risklər göstərir ki, AI-nin iqtisadi faydaları onun düzgün idarə olunmasından asılıdır.

Süni intellekt iqtisadi inkişafın ən mühüm determinantlarından birinə çevrilmişdir. O, məhsuldarlığı artırmaqla yanaşı, iqtisadi strukturun yenidən formalaşmasına səbəb olur, innovasiyanı sürətləndirir və rəqəmsal iqtisadiyyatın əsasını təşkil edir. Lakin AI-nin yaratdığı imkanlardan tam istifadə etmək üçün institusional uyğunlaşma, insan kapitalının inkişafı və etik idarəetmə mexanizmlərinin formalaşdırılması vacibdir. Süni intellektin (AI) inkişafı yalnız iqtisadi fəaliyyətə deyil, həm də idarəetmə sistemlərinin mahiyyətinə və strukturuna fundamental təsir göstərmişdir (OECD, 2025; Yue et al., 2026; Chouman, 2025). Müasir dövrdə idarəetmə artıq ənənəvi bürokratik modellərdən uzaqlaşaraq məlumat əsaslı, adaptiv və proqnozlaşdırıcı sistemlərə doğru transformasiya olunur (Kapartziani, 2025; ScienceDirect, 2025). Bu transformasiyanın mərkəzində isə süni intellekt dayanır. AI idarəetmə sistemlərini daha çevik, şəffaf və effektiv etməklə yanaşı, qərarvermə proseslərini köklü şəkildə yenidən formalaşdırır (Westover, 2025; Atieh et al., 2026).

Rəqəmsal idarəetmə (Digital Governance) dövlət və təşkilatların fəaliyyətində informasiya texnologiyalarının sistemli tətbiqini nəzərdə tutur (Bokhari et al., 2025; Gafsi et al., 2026). AI bu modeldə əsas komponent kimi çıxış edir və aşağıdakı imkanları yaradır:
- dövlət xidmətlərinin avtomatlaşdırılması
- vətəndaşlara fərdiləşdirilmiş xidmətlərin göstərilməsi
- qərarvermə prosesində məlumatların effektiv istifadəsi
- korrupsiya risklərinin azaldılması (OECD, 2025; Chouman, 2025; ScienceDirect, 2025).

AI əsaslı "e-government" sistemləri vətəndaş–dövlət münasibətlərini daha şəffaf və interaktiv edir. Bu isə idarəetmədə etimadın artmasına səbəb olur (Yue et al., 2026; Nature Sustainability, 2025).

Müasir idarəetmə sistemlərində məlumat əsas resurs kimi çıxış edir. AI bu məlumatların emalı və analizi üçün əsas alət rolunu oynayır.
Məlumat əsaslı idarəetmə aşağıdakı xüsusiyyətlərlə xarakterizə olunur:
- real vaxt rejimində qərarvermə
- böyük verilənlərin analizi (Big Data analytics)
- proqnozlaşdırıcı modellər
- siyasətlərin effektivliyinin ölçülməsi

Bu yanaşma sayəsində dövlətlər və təşkilatlar daha əsaslandırılmış və strateji qərarlar qəbul edə bilir (OECD, 2025; Yue el al.,2026).

Süni intellekt idarəetmədə qərarvermə mexanizmini dəyişir. Ənənəvi qərarvermə modelləri intuisiya və məhdud məlumatlara əsaslanırdısa, AI bu prosesi:
- avtomatlaşdırır
- optimallaşdırır
- obyektivləşdirir

AI-nin qərarvermədə rolu aşağıdakı mərhələlərdə özünü göstərir:
1. məlumatların toplanması
2. analiz və modelləşdirmə
3. alternativlərin qiymətləndirilməsi
4. optimal qərarın seçilməsi

Bu proses nəticəsində qərarların dəqiqliyi və sürəti əhəmiyyətli dərəcədə artır.

Nəticələr

AI texnologiyaları ağıllı idarəetmə sistemləri (Smart Governance) anlayışının formalaşmasına səbəb olmuşdur (Yue et al., 2026; OECD, 2025; Chouman, 2025). Bu model aşağıdakı xüsusiyyətləri ilə fərqlənir:

- adaptivlik (dəyişən şəraitə uyğunlaşma)
- proqnozlaşdırma qabiliyyəti
- inteqrasiya olunmuş idarəetmə sistemləri
- vətəndaş iştirakının artırılması (Kapartziani, 2025; ScienceDirect, 2025).

Ağıllı şəhər (smart city) konsepsiyaları bu yanaşmanın praktiki tətbiqidir. Burada AI nəqliyyat, enerji, təhlükəsizlik və kommunal xidmətlərin idarə olunmasında geniş istifadə olunur r (Gafsi et al., 2026; Nature Sustainability, 2025).

Süni intellekt yalnız dövlət idarəçiliyində deyil, həm də korporativ idarəetmədə mühüm rol oynayır. Şirkətlər AI vasitəsilə:
- strateji planlaşdırmanı təkmilləşdirir
- riskləri daha effektiv idarə edir
- bazar davranışını proqnozlaşdırır
- əməliyyat səmərəliliyini artırır (Kapartziani, 2025; Bokhari et al., 2025)

AI əsaslı idarəetmə şirkətlərə rəqabət üstünlüyü qazandırır və qərarvermə prosesini daha çevik edir (OECD, 2025).

Süni intellektin idarəetmədə tətbiqi yeni etik və hüquqi problemlər yaradır (ScienceDirect, 2025; OECD, 2025; Yue et al., 2026). Bu problemlər əsasən aşağıdakı sahələri əhatə edir:
- alqoritmik qərəz (bias): qərarların qeyri-obyektiv olması
- məxfilik: şəxsi məlumatların qorunması
- hesabatlılıq: qərarların kim tərəfindən verildiyinin müəyyən edilməsi
- səffaflıq: AI alqoritmlərinin izah oluna bilməsi (Chouman, 2025; Kapartziani, 2025)

Bu problemlərin həlli üçün etik AI prinsipləri və hüquqi tənzimləmə mexanizmləri zəruridir.

Süni intellektin effektiv idarəetmədə tətbiqi üçün aşağıdakı model təklif olunur (Yue et al., 2026; Chouman, 2025):
A – Accountability (Hesabatlılıq)
AI qərarlarının izah oluna bilməsi və məsuliyyət mexanizmlərinin müəyyənləşdirilməsi
E – Ethics (Etika)
Ədalətli və qərəzsiz alqoritmlərin yaradılması
I – Integration (İnteqrasiya)
AI-nin mövcud idarəetmə sistemlərinə uyğunlaşdırılması

A – Adaptability (Adaptivlik)
Dəyişən mühitə uyğunlaşa bilən sistemlər
T – Transparency (Şəffaflıq)
Qərarvermə proseslərinin açıq və izah edilə bilən olması

Bu model dayanıqlı və effektiv idarəetmə üçün əsas çərçivə rolunu oynayır (OECD, 2025; Westover, 2025). Qlobal idarəetmə və süni intellect AI texnologiyalarının sürətli inkişafı qlobal idarəetmə səviyyəsində yeni çağırışlar yaradır (Atieh et al., 2026; ScienceDirect, 2025). Dövlətlər arasında:

- texnoloji rəqabət artır
- məlumat təhlükəsizliyi məsələləri aktuallaşır
- beynəlxalq tənzimləmə ehtiyacı yaranır (Yue et al., 2026; OECD, 2025).

Bu səbəbdən AI üçün qlobal etik və hüquqi standartların formalaşdırılması vacibdir (Nature Sustainability, 2025; Chouman, 2025).

AI əsaslı idarəetmə sistemlərinin bəzi məhdudiyyətləri mövcuddur (OECD, 2025; ScienceDirect, 2025; Chouman, 2025):

- texnoloji asılılıq
- insan faktorunun azalması
- sistem səhvlərinin geniş təsiri
- qərarların "qara qutu" xarakteri (Kapartziani, 2025; Yue et al., 2026).

Bu risklər göstərir ki, AI tam avtomatik idarəetmə modeli deyil, insan–texnologiya əməkdaşlığı modeli kimi tətbiq olunmalıdır (Westover, 2025).

Süni intellekt idarəetmə sistemlərini köklü şəkildə transformasiya edərək onları daha effektiv, şəffaf və adaptiv edir. O, qərarvermə proseslərini optimallaşdırır, məlumat əsaslı idarəetməni mümkün edir və həm dövlət, həm də korporativ səviyyədə yeni idarəetmə modellərinin formalaşmasına şərait yaradır (Atieh et al., 2026; Bokhari et al., 2025). Lakin bu transformasiyanın uğurlu olması üçün etik, hüquqi və institusional çərçivələrin inkişafı zəruridir (OECD, 2025; Nature Sustainability, 2025). Onuda qeyd edim ki, dayanıqlı idarəetmə (Sustainable Governance) müasir idarəetmə nəzəriyyəsində iqtisadi səmərəliliklə yanaşı sosial ədalət və ekoloji balansın qorunmasını təmin edən kompleks yanaşma kimi formalaşmışdır (Gafsi et al., 2026; Atieh et al., 2026). Bu yanaşmanın əsas məqsədi qərarvermə proseslərini uzunmüddətli təsirlər baxımından optimallaşdırmaq və gələcək nəsillərin maraqlarını nəzərə almaqdır(Nature Sustainability, 2025). Süni intellekt (AI) isə bu məqsədlərə nail olmaq üçün idarəetmə sistemlərinə yeni imkanlar qazandıran əsas texnoloji platforma kimi çıxış edir.

Dayanıqlı idarəetmə anlayışı United Nations tərəfindən qəbul edilmiş Dayanıqlı İnkişaf Məqsədləri (SDGs) ilə sıx bağlıdır və üç əsas prinsip üzərində qurulur (Atieh et al., 2026; Gafsi et al., 2026):

- uzunmüddətli planlaşdırma – qısa müddətli deyil, strateji qərarlar
- inklüzivlik – bütün sosial qrupların iştirakının təmin edilməsi
- balanslı inkişaf – iqtisadi, sosial və ekoloji komponentlərin harmoniyası (Nature Sustainability, 2025).

Bu yanaşma ənənəvi idarəetmə modellərindən fərqli olaraq yalnız nəticəyə deyil, həm də prosesin davamlılığına fokuslanır (Chouman, 2025).

Süni intellekt dayanıqlı idarəetmənin effektivliyini aşağıdakı əsas mexanizmlərlə artırır (Yue et al., 2026; OECD, 2025):

1. Proqnozlaşdırıcı idarəetmə (Predictive Governance)

AI böyük verilənləri analiz edərək gələcək riskləri və trendləri əvvəlcədən müəyyən edir. Məsələn:

- iqlim dəyişikliklərinin təsiri
- iqtisadi böhranların proqnozu
- sosial problemlərin erkən aşkarlanması (Nature Sustainability, 2025)

2. Resursların optimallaşdırılması
AI enerji, su və digər resursların istifadəsini optimallaşdıraraq ekoloji dayanıqlılığı gücləndirir (Gafsi et al., 2026; Bokhari et al., 2025).
3. Qərarvermənin keyfiyyətinin artırılması
AI əsaslı sistemlər qərarverməni:
- daha obyektiv
- daha sürətli
- daha əsaslandırılmış edir (Westover, 2025; Kapartziani, 2025).

Dayanıqlı idarəetmədə mühüm yanaşmalardan biri ESG (Environmental, Social, Governance) modelidir.

AI bu modelin tətbiqini gücləndirir:
E – Environmental (Ekoloji)
- karbon emissiyalarının monitorinqi
- enerji səmərəliliyinin artırılması

S – Social (Sosial)
- sosial xidmətlərin optimallaşdırılması
- inklüziv siyasətlərin hazırlanması

G – Governance (İdarəetmə)
- şəffaf qərarvermə
- korrupsiyanın azaldılması

Beləliklə, AI ESG indikatorlarının ölçülməsi və idarə olunmasını daha effektiv edir.

AI əsaslı dayanıqlı idarəetmə modeli (genişləndirilmiş AEIAT)
Süni intellektin dayanıqlı idarəetmədə tətbiqi üçün AEIAT modeli daha da genişləndirilə bilər:
A – Accountability (Hesabatlılıq)
AI qərarlarının izah olunması və məsuliyyətin müəyyən edilməsi
E – Ethics (Etika)
Ədalətli və diskriminasiyasız alqoritmlərin yaradılması
I – Integration (İnteqrasiya)
AI-nin idarəetmə strukturlarına uyğunlaşdırılması
A – Adaptability (Adaptivlik)
Dəyişən mühitə uyğunlaşma qabiliyyəti
T – Transparency (Şəffaflıq)
Qərarların açıq və izlənilə bilən olması
Bu model dayanıqlı idarəetmənin texnoloji və institusional əsasını təşkil edir.

AI texnologiyaları ağıllı və dayanıqlı sistemlər (Smart & Sustainable Systems) anlayışını formalaşdırır (Gafsi et al., 2026; Nature Sustainability, 2025; Atieh et al., 2026). Bu sistemlərdə:
- ağıllı şəhərlər (smart cities)
- ağıllı enerji şəbəkələri
- ağıllı nəqliyyat sistemləri bir-biri ilə inteqrasiya olunmuş şəkildə fəaliyyət göstərir (Kapartziani, 2025; Yue et al., 2026).

Bu yanaşma həm resursların qənaətli istifadəsini təmin edir, həm də həyat keyfiyyətini artırır.

Süni intellekt dövlət idarəçiliyində dayanıqlılığı aşağıdakı istiqamətlərdə artırır (Bokhari et al., 2025; OECD, 2025):
- sosial siyasətlərin effektiv planlaşdırılması
- səhiyyə və təhsil sistemlərinin optimallaşdırılması
- fövqəladə halların idarə olunması (Chouman, 2025; ScienceDirect, 2025).

Bu, xüsusilə pandemiya, iqlim dəyişiklikləri və iqtisadi böhranlar kimi qlobal problemlərin idarə olunmasında mühüm əhəmiyyət kəsb edir.

AI-nin dayanıqlı idarəetmədə tətbiqi ilə bağlı əsas risklər (OECD, 2025; ScienceDirect, 2025; Yue et al., 2026) mövcuddur:
Etik risklər
- alqoritmik qərəz
- diskriminasiya

Sosial risklər
- rəqəmsal bərabərsizlik
- texnoloji işsizlik (Kapartziani, 2025; Westover, 2025)

Ekoloji risklər
- yüksək enerji istehlakı
- karbon izi

Bu risklər göstərir ki, AI dayanıqlılıq üçün həm imkan, həm də risk mənbəyidir.

Süni intellektin dayanıqlı idarəetmədə rolu qlobal səviyyədə də aktuallaşır. Dövlətlər və beynəlxalq təşkilatlar AI üçün:
- etik standartlar
- hüquqi çərçivələr
- beynəlxalq əməkdaşlıq mexanizmləri

formalaşdırmağa çalışır (Chouman, 2025; ScienceDirect, 2025).
Bu, qlobal dayanıqlı inkişafın təmin olunması üçün vacibdir. Süni intellekt dayanıqlı idarəetmənin əsas texnoloji sütununa çevrilmişdir. O, qərarvermə proseslərini təkmilləşdirir, resursların səmərəli istifadəsini təmin edir və ESG prinsiplərinin tətbiqini gücləndirir. Lakin AI-nin dayanıqlı idarəetmədə effektiv istifadəsi yalnız texnoloji deyil, həm də etik, hüquqi və institusional yanaşmaların inteqrasiyasını tələb edir. Bu baxımdan, gələcək idarəetmə modelləri insan–AI əməkdaşlığına əsaslanan hibrid sistemlər kimi formalaşmalıdır.

Perspektivlər və gələcək istiqamətlər

Süni intellektin (AI) və rəqəmsal transformasiyanın sürətli inkişafı iqtisadi sistemlər, idarəetmə strukturları və dayanıqlı inkişaf strategiyaları üçün yeni perspektivlər açır(Atieh et al., 2026; OECD, 2025; Yue et al., 2026). Gələcək istiqamətlərin təhlili göstərir ki, AI yalnız mövcud prosesləri optimallaşdırmaqla kifayətlənmir, həm də tamamilə yeni iqtisadi və idarəetmə paradiqmalarının formalaşmasına səbəb olur(Westover, 2025; Chouman, 2025). Bu baxımdan, perspektivlər həm texnoloji, həm institusional, həm də sosial aspektlərdə kompleks şəkildə qiymətləndirilməlidir (Kapartziani, 2025; Nature Sustainability, 2025).

Gələcək inkişafın əsas istiqamətlərindən biri AI sistemlərinin insan dəyərlərinə uyğunlaşdırılmasıdır (European Commission, 2024; OECD, 2025). Bu yanaşma aşağıdakı prinsipləri əhatə edir:
- etik və məsuliyyətli AI
- istifadəçi yönümlü dizayn
- sosial rifahın prioritetləşdirilməsi

Bu kontekstdə European Commission tərəfindən irəli sürülən “Trustworthy AI” konsepsiyası xüsusi əhəmiyyət kəsb edir.

Süni intellektin qlobal təsiri onun beynəlxalq səviyyədə tənzimlənməsini zəruri edir (UN, 2025, Atieh, A., et al., 2026)). Gələcəkdə aşağıdakı istiqamətlərdə inkişaf gözlənilir:
- beynəlxalq AI hüquq normalarının yaradılması
- etik standartların harmonizasiyası
- məlumatların qlobal idarə olunması

Bu prosesdə OECD və United Nations kimi qurumların rolu artacaq.

Yaşıl süni intellekt (Green AI) və ekoloji dayanıqlılıq

AI texnologiyalarının enerji istehlakı ilə bağlı problemləri "Green AI" yanaşmasının formalaşmasına səbəb olmuşdur. Bu istiqamət aşağıdakı hədəfləri əhatə edir:
- enerji səmərəli alqoritmlərin hazırlanması
- karbon emissiyalarının azaldılması
- dayanıqlı data mərkəzlərinin yaradılması

Bu yanaşma AI-nin ekoloji təsirlərini minimuma endirməyə yönəlmişdir.
Gələcəkdə iqtisadi sistemlər daha çox aşağıdakı xüsusiyyətlərlə xarakterizə olunacaq:
- platform əsaslı iqtisadiyyatın genişlənməsi
- məlumatın əsas iqtisadi resursa çevrilməsi
- süni intellektin dəyər yaradıcı funksiyasının güclənməsi

Bu kontekstdə "AI economy" anlayışı formalaşır və ənənəvi iqtisadi modelləri əvəz edir.

Müzakirə

AI-nin inkişafı əmək bazarında fundamental dəyişikliklər yaradacaq. Gələcəkdə:

- avtomatlaşdırma səviyyəsi artacaq

- yeni peşələr yaranacaq

- ömürboyu təhsil (lifelong learning) zəruri olacaq

Bu prosesdə insan kapitalının inkişafı əsas prioritetə çevriləcək.
Gələcək idarəetmə modelləri aşağıdakı xüsusiyyətlərlə fərqlənəcək:
- real vaxt qərarvermə sistemləri
- proqnozlaşdırıcı siyasət modelləri
- AI əsaslı dövlət xidmətləri

Bu yanaşma "Government as a Platform" modelinə keçidi sürətləndirəcək.
Gələcəkdə AI və ESG prinsiplərinin inteqrasiyası daha sistemli xarakter alacaq:
- ESG indikatorlarının avtomatik ölçülməsi
- korporativ hesabatlılığın artırılması
- dayanıqlı investisiyaların genişlənməsi

Bu proses maliyyə və idarəetmə sistemlərində şəffaflığı gücləndirəcək.
AI digər qabaqcıl texnologiyalarla inteqrasiya olunaraq yeni innovasiya mərhələsi yaradacaq:
- AI + IoT (Əşyaların İnterneti)
- AI + Blockchain
- AI + Quantum Computing

Bu konvergensiya iqtisadi və idarəetmə sistemlərinin daha kompleks və effektiv olmasına gətirib çıxaracaq.

Risklər və qeyri-müəyyənliklər

Gələcək inkişafla yanaşı müəyyən risklər də qalmaqdadır:
- texnoloji asılılığın artması
- kiber təhlükəsizlik problemləri
- sosial bərabərsizliyin dərinləşməsi
- etik dilemmlər

Bu risklərin idarə olunması gələcək siyasətlərin əsas istiqamətlərindən biri olacaq.

Gələcək tədqiqat istiqamətləri (Research Agenda)

Elmi baxımdan aşağıdakı istiqamətlər prioritet hesab olunur:

- AI-nin SDG-lərə təsirinin empirik analizi
- AI və iqtisadi artım arasında səbəb-nəticə əlaqələrinin öyrənilməsi
- etik AI modellərinin hazırlanması
- AI idarəetmə sistemlərinin müqayisəli təhlili

Nəticə

Gələcək perspektivlər göstərir ki, süni intellekt iqtisadi inkişafın və idarəetmə sistemlərinin əsas transformasiyaedici qüvvəsi olaraq qalacaq. Onun təsiri yalnız texnologiya sahəsi ilə məhdudlaşmayacaq, həm də sosial, iqtisadi və institusional sistemləri yenidən formalaşdıracaq. Lakin bu potensialın reallaşdırılması üçün qlobal əməkdaşlıq, etik yanaşma və inklüziv siyasətlərin tətbiqi vacibdir. Onu qeyd etmək olar ki, süni intellekt rəqəmsal transformasiyanın əsas elementi kimi dayanıqlı iqtisadi inkişaf və idarəetmə sistemlərinin formalaşmasında mühüm rol oynayır. AI texnologiyaları iqtisadi səmərəliliyi artırmaqla yanaşı, idarəetmə proseslərini optimallaşdırır və innovasiyaları stimullaşdırır. Bununla belə, bu texnologiyaların effektiv istifadəsi üçün etik, hüquqi və institusional çərçivələrin inkişaf etdirilməsi zəruridir.

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The Establishment of Azerbaijan's Diplomatic Representation in Israel: Historical, Economic, and Military-Political Determinants

Majnun Hasanov

Abstract. *This article examines the historical, economic and military-political reasons for the opening of the Embassy of the Republic of Azerbaijan in Israel in the first quarter of 2023. The opening of the official diplomatic representation of the Republic of Azerbaijan in Israel is considered by both Azerbaijani and Israeli political experts as the culmination of relations between the two countries. Israel was one of the first states to recognize the Republic of Azerbaijan, which had just declared its independence in October 1991, on December 25, 1991. Within a short period of time — 103 days later, on April 7, 1992, de jure diplomatic relations were established between the two countries, and in August 1993, Israel elevated these relations to the level of embassy. The close relations between the two countries are considered by the international community to be based mainly on economic interests. However, this approach does not fully reflect the historical depth of the relations. The history of relations between the Azerbaijani and Jewish peoples goes back millennia. The Jewish community, which has lived in Azerbaijan for centuries, has played an important role in the formation and development of these relations. However, despite all these positive factors, Azerbaijan has long postponed the opening of its official diplomatic mission in Israel due to a number of regional-geopolitical reasons. Azerbaijan's membership in the Organization of Islamic Cooperation, the Karabakh conflict, the Iranian factor in the region, and other reasons have delayed the opening of a de jure diplomatic mission in Israel.*

Keywords: *Azerbaijan – Israel relations, Armenia, Energy security, Iran – Azerbaijan relations, Military cooperation, Nagorno – Karabakh war, Regional actors*

University of Vizja in Warsaw, Warsaw, Poland
E-mail: majnun.hasanov@mail.ru
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Azərbaycanın İsraildə Diplomatik Nümayəndəliyinin yaradılması: Tarixi, iqtisadi və hərbi-siyasi amillər

Məcnun Həsənov

Xülasə. *Bu məqalə 2023-cü ilin birinci rübündə Azərbaycan Respublikasının İsraildə səfirliyinin açılmasının tarixi, iqtisadi və hərbi-siyasi səbəblərini araşdırır. Azərbaycan Respublikasının İsraildə rəsmi diplomatik nümayəndəliyinin açılması həm Azərbaycan, həm də İsrail siyasi ekspertləri tərəfindən iki ölkə arasındakı münasibətlərin kulminasiyası kimi qiymətləndirilir. 1991-ci ilin oktyabrında müstəqilliyini yenicə elan etmiş Azərbaycan Respublikasını İsrail 25 dekabr 1991-ci ildə tanıyan ilk dövlətlərdən biri olmuşdur. Qısa müddət ərzində — 103 gün sonra, 7 aprel 1992-ci ildə iki ölkə arasında de jure diplomatik münasibətlər qurulmuş, 1993-cü ilin avqust ayında isə İsrail bu*

münasibətləri səfirlik səviyyəsinə qaldırmışdır. İki ölkə arasında mövcud olan sıx münasibətlər beynəlxalq ictimaiyyət tərəfindən əsasən iqtisadi maraqlara əsaslanan əlaqələr kimi qiymətləndirilir. Lakin bu yanaşma münasibətlərin tarixi dərinliyini tam əks etdirmir. Azərbaycan və yəhudi xalqları arasında münasibətlərin tarixi minilliklərə gedib çıxır. Əsrlər boyu Azərbaycanda yaşayan yəhudi icması bu münasibətlərin formalaşması və inkişafında mühüm rol oynamışdır. Bununla belə, bütün bu müsbət amillərə baxmayaraq, Azərbaycan bir sıra regional-geosiyasi səbəblərə görə uzun müddət İsraildə rəsmi diplomatik nümayəndəliyinin açılmasını təxirə salmışdır. Azərbaycanın İslam Əməkdaşlıq Təşkilatına üzvlüyü, Qarabağ münaqişəsi, regionda Iran amili və digər səbəblər İsraildə de jure diplomatik nümayəndəliyin açılmasını gecikdirmişdir.

Açar sözlər: *Azərbaycan–İsrail münasibətləri, Ermənistan, Enerji təhlükəsizliyi, Iran–Azərbaycan münasibətləri, Hərbi əməkdaşlıq, Dağlıq Qarabağ müharibəsi, Regional aktorlar*

Varşava Vizja Universiteti, Varşava, Polşa
E-poçt: majnun.hasanov@mail.ru
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Introduction

This study examines the formal institutionalization of these relations 31 years after the Republic of Azerbaijan established diplomatic relations with Israel on April 7, 1992. The topic of The Establishment of Azerbaijan's Diplomatic Representation in Israel: Historical, Economic, and Military-Political Determinants is an important area of scientific research in terms of both historical and political context.

Following the collapse of the USSR, which had existed for nearly 70 years (1922, December 30 – 1991, December 26), many new independent states emerged, including Azerbaijan, located in the Caucasus region on the shores of the Caspian Sea. After Azerbaijan declared its independence, Israel, located in the Middle East, was among the first countries to recognize it, following Turkey, a key regional partner of Azerbaijan. On December 25, 1991, Israel officially recognized Azerbaijan's independence, and bilateral diplomatic ties were established on April 7, 1992 (Avinoam & Shaffer, 2021, p. 191). The end of the Cold War was an essential factor in the formation of the Israeli–Azerbaijani entente. The memory of the historic good ties between the Jewish Community and the Azerbaijani majority was a crucial psychological element that added legitimacy and continuity to the upgraded Israeli–Azerbaijani relations (Murinson, 2014, p. 10). The Republic of Azerbaijan, which declared its independence on October 18, 1991, has attached special importance to establishing relations with the State of Israel since the first years of its independence. Thus, at the initial stage — during 1991–2008 — relations with Israel were formed and consistently developed in both bilateral and multilateral formats in the foreign policy of the Republic of Azerbaijan. In particular, after the presidential elections held in October 2003, Azerbaijani–Israeli relations entered a new stage, and strategic cooperation between the two countries deepened. The diplomatic relations between Baku and Tel Aviv, which have been steadily strengthening over time, have attracted the attention of the world community. When we examine the development of relations between these two states in the past and recent history, we can see that these relations are not accidental. Building diplomatic relations with independent Azerbaijan was an opportunity for Israel to improve its image in the countries of the region, where Israel's regional legitimacy has historically beencontested. Moreover, recognizing Azerbaijan's independence seemed to the Israeli authorities to be a step towards improving its position in the United Nations as a state that, while in conflict with Arab countries, can maintain proper relations with another Islamic

country and to establish cooperation with new entities in international relations to facilitate Jewish immigration to Israel. One of the main factors determining the relevance of the topic is the important role played by the Jewish community in Azerbaijan and Azerbaijani Jews living in Israel in the development of relations between the two peoples and states in modern times. The chronological framework of the study covers the years 1991–2023. The beginning of the chronological framework is from the restoration of the state independence of the Republic of Azerbaijan in 1991, and its final boundary ends with the opening of the official diplomatic representation of the Republic of Azerbaijan in Israel in 2023. The existing chronological framework allows us to examine all areas of the current relations between the Republic of Azerbaijan and the State of Israel and to follow the dynamics of their development. The object of the study is the mutual relations formed between the Republic of Azerbaijan and the State of Israel during 1991–2023 and the process of institutionalization of these relations.

The subject of the research is the study of the main factors determining the bilateral relations between the Republic of Azerbaijan and the State of Israel, as well as the main features of the formation and development of cooperation in the diplomatic-political, trade-economic, military, scientific-technical and cultural-humanitarian spheres. At the same time, the impact of Armenia's aggressive policy towards Azerbaijan and the Iranian factor in the region on these relations is also included in the subject of the study. Objectives and tasks of the study. The main objective of the study is to examine the relations between the Republic of Azerbaijan and the State of Israel in 1991–2023 from both a historical and diplomatic perspective. In order to achieve the set goal, the following tasks were attempted:

- To interpret and analyze the factors and historical circumstances that determine the diplomatic-political relations between the Republic of Azerbaijan and the State of Israel;
- To analyze and assess the main factors affecting the formation of mutual interests;
- To monitor the dynamics of the development of historical-political relations;
- To examine the attitude of the State of Israel to the Nagorno-Karabakh conflict created as a result of Armenia's military aggression against the Republic of Azerbaijan;
- To examine relations in the economic, scientific-technical and military spheres;
- To analyze the extent to which the Iranian factor accelerated the opening of the embassy in Israel;

Research methodology in this article the factors influencing the formation of Azerbaijani–Israeli relations and the decision of the Republic of Azerbaijan to open a diplomatic mission in Israel were investigated based on qualitative research methods.

1. The historical-comparative analysis method was used to systematically examine the historical-social foundations of the relations between Azerbaijanis and Jews, the Soviet period and the stages after independence. This method allowed us to explain the opening of the embassy in Israel as a long-term political process in chronological terms. The comparative analysis method was synthesized with historical analysis and allowed us to compare the pre-war and post-war stages of relations. Here, the historical analysis method also showed its influence.
2. Within the framework of the document analysis method, official state statements and sanctions, diplomatic documents, decisions of international organizations and analytical reports were analyzed. This method created conditions for determining the foreign policy discourse of states and the strategic nature of diplomatic decisions.
3. The case study method was applied to the example of the first and second Karabakh wars. The impact of the war on the security environment and the institutionalization of Azerbaijani–Israeli relations was analyzed using this method.
4. The analysis of international and national legal documents included the legal framework of diplomatic relations, the Vienna Convention, as well as the Constitution of the Republic of Azerbaijan and the Constitution of the Islamic Republic of Iran, as well as resolutions and decisions of the United Nations.

Source base of the research. The dissertation work was written on the basis of numerous sources in different languages. The theoretical and analytical base of the research was formed on the basis of academic books and scientific articles related to international relations, security studies and foreign policy. Official state documents and statements played an important role in the collection of empirical materials. During the research, reputable international media and analytical publications, as well as Internet resources, were also used as a supporting base.

1. The Historical Background of Azerbaijani-Jewish Relations and the First Interstate Relations

This chapter examines the historical roots of relations between Azerbaijan and the Jewish people, and analyzes how and in what stages modern Azerbaijani–Israeli relations were formed. The main problem posed during the research, why Azerbaijan has not opened its diplomatic representation in Israel since April 7, 1992, will be systematically analyzed, including geopolitical and regional reasons and factors. In recent years, Azerbaijan and Israel, two countries with predominantly Jewish and Muslim populations, with different ethnic, cultural, social and political structures, and not very similar in terms of economic development, have been increasingly approaching each other. This is attracting attention. This rapprochement, which began in the fields of diplomacy, trade and economic fraternity, is gradually turning into a strategic partnership, covering the fields of intelligence and security (Erdoğan, 2013, p. 21). Furthermore, Azerbaijan arose as the key pillar of Israeli cooperation in the South Caucasus and the geopolitical isthmus which allowed for the realization of the vision of a new "Turkic world" commonwealth that would prevent the Iranian penetration of Central Asian (Murinson, 2014, p. 9). In modern times, the Republic of Azerbaijan and the State of Israel maintain bilateral relations in political, economic, cultural, humanitarian and other areas. Political, economic, geopolitical, geostrategic factors and regional security issues have elevated the relations of the Republic of Azerbaijan with the State of Israel to the level of strategic partnership. In this context, Azerbaijani–Israeli relations have always been a topical subject of discussion by historians, politicians, and political analysts. In order to understand the development and formation of diplomatic and political relations between Azerbaijan and Israel, we must also examine the historical aspect of these relations. Then we will understand that it is not at all a coincidence that these relations officially began at the end of the 20th century and at the beginning of the 21st century, developed on an upward trajectory. It is known that the Mountain Jews came to the Caucasus from 722 BC onwards, during the Assyrian, Babylonian, Achaemenid, Sasanian, Ilkhanid, Safavid, and Afsharic periods, for various reasons. However, despite being a minority within the ethnic origins and cultures of the region, they managed to preserve their religious and national traditions. At the same time, sources indicate that the Mountain Jews were influenced by the customs and traditions of their environment. This interaction continues to this day in cultural life. In Azerbaijan, the Mountain Jews have become a part of their society in many areas, from their folk beliefs to social activities, food, and music. The peoples of moi Jewish who were in contact with the surrounding peoples, also maintained their relations with their co-religionists and educational centers, including digər yaxın ölkə və şəhərlərdəki (Georgia, Iran, Iraq, Jerusalem, Bukhara, etc.). However, they are not mentioned as a people in official documents from Tsarist Russia until the 19th century (Osmanlı & Güç, 2020, p. 51).

During the USSR, a number of Jewish communities, especially Mountain Jews, settled in Azerbaijan and considered these lands their native homeland. The main reason for this was that, compared to many other territories of the union republics, there was no discrimination and anti-Semitism against Jewish communities in Azerbaijan. It was this tolerant environment that created the conditions for the long-term and stable settlement of Jewish communities in Azerbaijan. However, at that time, Azerbaijan was subordinate to the Soviet government and decisions came from the center. Even after Israel declared its independence from a difficult geopolitical location in 1948, it could not establish official diplomatic relations with Azerbaijan for a long time. This was not because Azerbaijan did not want to establish relations with Israel, but because it could not. This is because Azerbaijan was part

of the Soviet Union from 1948 to 1991. The foreign policy of each member country of the union was determined from the center, that is, officially in Moscow. Even now, the world was divided into two blocs, with the United States supporting Israel, and the Soviet Union, in turn, supporting the Arab countries. Official diplomatic relations between Israel and Azerbaijan became possible only 44 years later, precisely after the collapse of the Soviet Union.

1.1. Settlement of Jews in Azerbaijan and historical and cultural heritage

The relations between these two peoples – Azerbaijanis and the Jewish people, who have no ethnic or religious ties with each other – have deep historical roots. It is necessary to pay attention to the historical and social relations that have existed between Jews and Azerbaijanis since ancient times. As is known, the Jewish people who migrated to Azerbaijan at different stages of history have tied their fate with these lands. There are different explanations for the settlement of the Mountain Jews in this territory, like that their origin comes from the Khazar Turks, who converted to Judaism or migrated from Persia nearly three hundred years ago (Saffron, 1998, pp. 46–47). But the commonly accepted theory is that Jews have been settled in the territory of Azerbaijan since the 5th century BC, after the destruction of the Jerusalem temple by Babylonian King Nebuchadnezzar in 586 BC. During his. Ruling period, a number of Jews from the Judean kingdom moved north to today's Azerbaijan. After the defeat of the Babylon Empire by the Achaemenian Empire in 539, King Cyrus of the Persian Empire decreed the return of the Jews to Jerusalem, but some of the Jewish population remained settled in the northern territory. This population became the Mountain Jews. They currently. Dominate the Jewish community in Azerbaijan and speak the distinct dialect of the Tat language known as Juhiri or Judaeo-Tat (Murinson, 2008, pp. 160–161). Azerbaijan has been home to various ethnic groups since ancient times, and they have lived in peace for many centuries, whether in the Middle Ages, during the years when Tsarist Russia and Soviet rule were established in Azerbaijan. It is especially important to note that from the time Jews settled in Azerbaijan until the modern era, there has never been a single conflict.

Methods

In this regard, the National Leader of the Republic of Azerbaijan, Heydar Aliyev, said: Jews have lived in Azerbaijan for centuries and there have never been any cases of discrimination against them. It is also known from history that some representatives of the Jewish people moved to Azerbaijan to escape the massacres and found a place where they could live peacefully without feeling discrimination. This is a characteristic of our people. This is also a demonstration of the policy pursued by the independent Azerbaijani state (Məmmədova, 2022, p. 15). From Heydar Aliyev's quote, we can conclude that Jews sought refuge in Azerbaijan in order to escape physical persecution and survive during certain bloody periods of history. Despite being under constant pressure, Azerbaijan, especially during the Tsarist and Soviet periods, not only provided shelter to Jews, but also created all kinds of favorable conditions for their integration into social life and society. After a long historical period, several Jewish communities have formed in Azerbaijan. There are three Jewish communities on the territory of Azerbaijan: Mountain Jews living in the areas of Guba and Baku, Mountain Ashkenazim living in Baku and Sumgayit, and a community of Georgian Jews in the areas bordering the Republic of Georgia. Historical sources show that Mountain Jews have been rooted in the territory of Azerbaijan since ancient times. Their ancestors arrived in the country in the Middle Ages, about 15 centuries ago (Shapiro, 2013, p. 6). These Jewish communities, which have not faced any anti-Semitism throughout history in Azerbaijan, have settled in these areas for a long time. However, throughout history, the presence of smaller groups such as the Krymchaks, Bukhara Jews, Kurdish Jews, Gerim and Suhbotniks has also been mentioned here (Hasanoğlu, 2022, p. 195).

The Ashkenazi Jews are a group settled in the region by the Russian Tsarist regime with the aim of imposing their own culture. However, this Ashkenazi community again came to Azerbaijan during

World War II, fleeing Nazi persecution (Marcus, 2009, p. 15). In particular, this historical process took place in the 18th century during the reign of Tsarina Elizabeth II of Tsarist Russia (1741–1762), when mainly people who had converted to Judaism were deported from the territory of Tsarist Russia and sent to Azerbaijan. They settled, european jewish compactly in the Privolneye settlement of the Ismayilli region. Before the Russian occupation of the Caucasus, the names of the Mountain Jews were not mentioned in official records and literature. The name Mountain Jews was given to them by Russian aauthorities in the half of the 19th century. After the annexation of the Caucasus to Russia, surnames such as Ashurov (son of Ashur), Sadikov (son of Sadiq), Shaulov (son of Shaul), Nisimov (son of Nisim), Danilov (son of Danil), Davidov (son of David) were created by adding "ov" to the end of the name, creating the name of the father or mother in Russian. There are also exceptional names and surnames such as Shomoil ben Ovşolom. When Dagestan became part of the Russian Empire in 1813, surnames were required because all merchants had to obtain a certificate of membership in the merchant guild. The surname Hanukayev was given in honor of the Jewish holiday of Hanukkah. There are also some surnames Peysahov and Abramov (Osmanlı & Güç, 2020, pp. 51–52).

At the beginning of the 19th century, Tsarist Russia began an expansionist policy in the Caucasus region to seize new lands. As a result, the Gulistan Peace Treaty was signed in 1813 as the final result of the war between Tsarist Russia and the Qajar state in 1801–1813. During this period, Tsarist Russia prepared a new demographic plan. The first Ashkenazi Jews were settled in the territory of the former Baku Khanate, the present city of Baku, after 1813.bIn 1832, only 26 Jews lived in Baku. In 1835, 5,492 Jews lived in Guba (2,718 of whom were concentrated in the form of a community). In 1866, their number had reached 6,282. In 1864, the majority of the population living in Vartashen (now Oghuz M. S.) was made up of Jews. In 1870, the first synagogue of craftsmen was opened. In 1886, 1,400 Jews lived here. They had 3 houses of worship and two Talmud-khuns, where 40 students were educated, and 70 literate Jews who could read the Torah (Eleven.co.il, n.d.).

The Mountain Jews, one of the Jewish communities that had settled in Azerbaijan centuries earlier, settled compactly in the early 19th century along the Caspian coast, near the North Caucasus, especially in the cities of Derbent and Guba. During the Caucasian Wars (1817–1864), the Russian army's punitive campaign against the Chechens, Avars, and Dagestanis was accompanied by continuous armed clashes the mountainous regions. In turn, the civilian population, especially the Mountain Jews, sought refuge in the interior of the North Caucasus, namely in Nalchik, Khasavyurt, Grozny, Temir-khan-shura and other cities, in order to protect their lives and property. This process led to an increase in the demographic presence of Mountain Jews in the North Caucasus, and these changes were also reflected in the official statistical materials of the 19th century.

The Russian military administration gave the name of Mountain Jews to the Jews of Dagestan and North Azerbaijan (Russian: Gorskie Evreu-Gorskiye Yevrei), seeing it as one of the many mountains of the Caucasus. Local Muslim peoples called them juhud or juhuds. According to the official census of Tsarist Russia in 1886, the total number of Mountain Jews in the Caucasus was recorded as 21,138 men, and they lived collectively in the 34 settlements listed below (Osmanlı & Güç, 2020, p. 52). These indicators are illustrated in Table 1.

Table 1
Settlements and numbers of Mountain Jews in the Caucasus in the first census of 1886

N⁰	Location	Number of Jews	Including women and people over 20 years old	Population growth rate taking into account death and birth	Note
1	Aglabi	33	15	2	
2	Karabudak	71	35	3	
3	Buynaksk	90	40	4	
4	Gimeyde	100	50	5	
5	Petrovsk	123	60	6	
6	Rukel	126	63	6	
7	Durgalı	130	65	6	
8	Cheriyurtı and Sulak	141	70	7	
9	Nutug	152	76	7	
10	Andrevka	157	75	7	
11	Hoshmenzil	167	84	8	
12	Muhtadir	232	116	11	
13	Hangal-gala	243	120	12	
14	Karchag	255	125	12	
15	Poselok Chekan	276	135	13	
16	Cherag	276	235	23	
17	Kustek	293	145	4	
18	Tarke	300	150	15	
19	Dashlaqar	309	105	15	
20	Temir Khan Shura	335	167	16	
21	Nalchik	335	167	16	
22	Hosrov Yurt	348	174	17	
23	Meclis	529	264	26	
24	Malrag	668	330	33	
25	Yani Kent	684	342	34	
26	Tashkala	690	340	34	
27	Haftaran Mug	692	340	34	
28	Arag	705	350	35	
29	Nuygedi Myushkur	778	389	38	
30	Mücü	957	470	47	
31	Oguzh	1396	698	70	
32	Grozny	1594	790	79	
33	Derbent	1671	835	83	
34	Guba, Jewish Quarter	6282	3141	31	
	Total	21138	10606	**769**	3.6%

Source: Jabir Osmanlı and Ahmet Güç, "Religious and Social Situation of Azerbaijan's Mountain Jews During Tsarist Russia and the Soviet Union," Journal of Theology Faculty of Bülent Ecevit University 7, no. 1 (2020): 54–55.

The statistical table from 1886 shows that the settlement pattern of Mountain Jews in the Caucasus region was not accidental, but a direct result of historical and political processes. The vast majority of the 21,138 people listed in the table were compactly settled in 4 specific settlements. Another aspect that is noteworthy is the unevenness of this demographic distribution.

For instance;

- Guba Jewish Settlement – 6,282 people, or approximately 29.7% of the total
- Derbend – 1,671 people (~7.9%)
- Grozny – 1,594 people (~7.5%)
- Oguz – 1,396 people (~6.6%)

These four settlements account for approximately 52% of the total population. The places where Jewish communities are compactly settled are the cities of Guba and Oghuz in the modern Republic of Azerbaijan, and the other two are the cities of Grozny and Derbent in the Russian Federation. This table shows that Jewish communities are concentrated in several strategic locations, while in peripheral areas, i.e., places outside the central political and economic structures, the areas of Aglabi (33), Karabudak (71), Buynaksk (90), and Gimeyde (100) are represented by small and weak communities. These types of settlements are characterized as transitional or temporary residential zones.

The main occupation of the Jews living in Northern Azerbaijan was agriculture, small trade and labor. Their economic situation was difficult. Since the 70s of the 19th century, Jews from western Russia began to flock to Azerbaijan in connection with the development of the oil industry in Baku. They began to play a major role in the development of the oil industry, which was an important sector of the national economy. They founded several firms. The firms created by G. A. Polyak Polyak and Sons, A. Dembo and H. Kagan Dembo and Kagan, G. Gintsburg Gintsburg and Family, and A. Fischel were of great importance. The Caspian-Black Sea Oil Industry and Trade Society created by the Rothschilds began to play a leading role at the beginning of the 20th century. Mechanical engineers A. Gukhman and M. Fin and engineering technologists D. Landau and I. Pilkevich were particularly active in this campaign (Akiner, 2004, pp. 90–91). The history of the settlement of Georgian Jews in Azerbaijan dates back to the 18th-19th centuries. After the abolition of serfdom in Russia in 1861, the arrival of Georgian Jews to Azerbaijan increased, as they had already gained freedom of movement. Until 1861, members of the Jewish communities in Georgia were in feudal dependence. After the abolition of this law, economic migration of Georgian Jews became inevitable, and for the first time, Georgian Jews were able to partially choose their location. The vast majority of this community settled in Baku. Because the mass migration of them started in the 1870s with the first oil boom in Azerbaijan. (Eleven.co.il, n.d.) They settled mainly in the oil-rich city of Baku. Already in the 70s of the 19th century, the development of the oil industry and investments in Baku led to urbanization and the expansion of the market economy. This is precisely why Georgian Jews were eager to settle in Baku.

The main occupation of Georgian Jews living in Icherisheher was petty trade. Most of them had kerosene stalls. Here they sold small items such as soap, mazut, etc. The situation of Georgian Jews was particularly difficult. They could not even get an education in secondary and higher schools. Therefore, the Georgian Jews Enlightenment Society began to operate in Baku. (Kaspiy.az, 2014) However, this society ceased its activities in April 1920, when the Soviet army attacked Baku and the Azerbaijan Democratic Republic collapsed.

1.2 Historical foundations of Azerbaijani–Israeli relations in the Azerbaijan Democratic Republic and the Soviet period (1918–1990)

To understand the history of the formation of Azerbaijani–Israeli relations more deeply, it is not enough to look at these relations only within the framework of 1992–1993. It is necessary to analyze these relations within the framework of the period before the independence of the Republic of Azerbaijan, within a broader historical and political context. In this regard, the principles of statehood formed during the Azerbaijan Democratic Republic, the political restrictions that existed during the years of Soviet rule, and finally, the complex international and domestic conditions that emerged in

the first years of independence played an important role in shaping the initial foundations of Azerbaijani–Israeli relations.

During its 1 year and 23 months of rule in 1918–1920, the ADR was the first parliamentary democratic republic in the Muslim East, and it also treated all citizens living within the country's borders, regardless of their national, religious, or ethnic affiliation, with equal rights. During the ADR, there were many national minorities, one of which was the Jewish community. The Jewish community in Azerbaijan continued to grow after the formation of the Azerbaijan Democratic Republic on May 28, 1918. Article 4 of the Azerbaijan Democratic Republic's Declaration of Independence guarantee to all its citizens within its borders, full civil and political rights, regardless of ethnic origin, religion, class, profession, or sex (Asadov, 2023, p. 70). Like many peoples living in the territory of the ADR, the absence of any systematic restrictions on the religious and cultural activities of the Jewish communities, and the fact that these peoples lived within the borders of the ADR in an integrated manner into society, demonstrated that the traditions of multiculturalism and tolerance were officially accepted at the state level. Considering the importance of the participation of people's representatives in resolving political issues, the founders of our Republic decided to form a parliament. The law on the establishment of the Azerbaijani parliament was adopted by the National Council on November 20, 1918. Secular and democratic principles were taken as the basis when determining its composition (Ismayilova, 2023, p. 42). Secular and democratic principles were taken as the basis when determining its composition. These rights recognized by the newly established Azerbaijan Democratic Republic to its citizens, also allowed the Jewish people living in the country to operate freely and independently in the economic, political, and social life of the state. There were 80 Muslims, 21 Armenians, 10 Russians, 1 German, 1 Polish and 1 Jew in the Azerbaijan Democratic Republic's National Council (Asadov, 2023, p. 70).

During the ADR period, the representation of representatives of various peoples and communities in the parliament is not a coincidence. Because it was a conscious decision arising from the ideological, legal and political foundations of the state. Since the ADR was founded on the basis of the republican model, the idea of political representation of the people was at the forefront. Taking this reality into account, the integration of all strata of society into the state was an institutional expression of the policy of multiculturalism and tolerance. "Despite all the pressure and difficulties, the parliament was opened in Azerbaijan for the first time in the Muslim East on December 7, 1918. In addition to Russians, Armenians, and Georgians, representatives of minority nations were also represented in the parliament, one from each of Poles, Germans, Jews, and Ukrainians. Representatives of these nations represented in the parliament united and formed the National Minorities faction in accordance with the requirements of the parliamentary charter on the creation of factions (Ismayilova, 2023, p. 42).

Some prominent members of the Jewish community have been given high positions in the Cabinet of Ministers of the Azerbaijani National Council. The composition of the government changed several times but there were always 1–2 Jews here as a minister, or deputy minister. In the third cabinet of the Azerbaijan Democrat-ic Republic, which functioned from December 1918 to March 1919, Y. Gindes served as Minister of Public Health, and K. Lisgar as Minister of Food. R. Kaplan served as Minister of Education and Religious Affairs in the ADR's fourth cabinet, which ran from March to December 1919. In addition to receiving education in their native language, the Jews published periodicals in Russian, Yiddish, Juhut and Hebrew during the years of the Azerbaijan Democratic Republic under various names: Kavkazskii evreiskii vestnik (The Caucasus Jewish Vestnik), Molodoj Siona (The Young Sion), Palestina (Palestin) and one period-ical in the Dzhuhuri dialect Tobushi Sabakhi (Sunrise) (Asadov, 2023, p. 71). Despite the strengthening of anti-Semitism in many countries of the world during this period, Jewish communities in Azerbaijan lived in relatively safe and stable conditions. The policy of tolerance and legal equality implemented by the Azerbaijan Democratic Republic in relation to national and religious minorities allowed Jews to function in an integrated manner in society. However, this positive development process ended with the occupation

of Baku by the XI Red Army on April 28, 1920, and with the establishment of Soviet power in the country, serious changes occurred in the legal and political status of national minorities.

After the occupation of the Azerbaijan Democratic Republic by the Red Army in 1920, Soviet Rule was established in Azerbaijan. Russia was one of the birthplaces of anti-Semitism in Europe, and during the civil war in Russia after the 1917 Bolshevik Revolution, following their anti-Semitist attitude, soldiers of Red Army engaged in a pogrom against the Jewish population, killing tens of thousands of Jews between 1918 and 1920. However, this policy was also continued in Azerbaijan through a different approach by the occupation of Azerbaijan (Abilov, 2009, p. 149). Thus, the democratic legal institutions inherited from the ADR period were abolished, and although the rights of national minorities were formally protected, in fact, serious restrictions were imposed. Political rights were completely eliminated, the parliamentary system governed on democratic principles and multi-party political representation were abolished. With political decisions coming under the sole control of the Communist Party, the faction of national minorities had already lost its role in the socio-political life of the state. Religious freedoms implemented a policy of suppression of national identity and assimilation against the Jewish community, along with Azerbaijanis. During the period of atheism, especially in the 1920s and 1930s of the twentieth century, the use of administrative violence led to the destruction of many places of worship and the repression of thousands of clergy and laity. In the 1920s, the activities of all Zionist organizations and related cultural and educational institutions that worked in Hebrew were banned. However, cultural development con-tinued in other Jewish languages. There were Yiddish and Jewish-Tat schools in Baku; the famous teacher F. Shapiro taught here. Mountain Jewish schools also functioned in other cities of the republic until 1938, when most of the schools of national minorities were closed. Other cities of the republic until 1938, when most of the schools of national minorities were closed. The Mountain Jewish Department of the Azerbaijan State Publishing House, managed by Y. Agarunov and headed by Y. Semenov, published the periodical Kommunist in the Jewish-Tat language in Azerbaijan from 1934 until 1938 (Azerbaijan Jews, 2004). It was during this period that many Jews left Azerbaijan and emigrated to various countries. Despite the fact that the Jewish communities in the Azerbaijan Soviet Socialist Republics suffered from the harsh.

Police of the Soviet regime in the 1920s and 1930s, their mass influx to Azerbaijan during the Great Patriotic War (1941–1945) can be explained by a number of objective and historical factors. The territories occupied by Nazi Germany in the summer of 1941 were also subjected to genocide. At the same time, the wave of anti-Semitism raging in Europe also prompted European Jews to return to other Jewish communities that had once lived in peace in Azerbaijan. The influx of Jews from Ukraine, Moldova, Belarus, the Baltic States and Russia to Azerbaijan during the Great Patriotic War is once again an indicator of the tolerance of the local population. During the Second World War, a ruthless policy was pursued in Germany against the Jews. Representatives of this people were massively exterminated. Jews who were together with Azerbaijanis in fascist captivity were also killed. In such circumstances, Azerbaijani prisoners gave the Jews Azerbaijani names and surnames, taught them the kelmeyi-shehadet, and saved them from death (Qasımlı, 2006, p. 652).

In 1948, the Jewish people declared their national state – the state of Israel – in a geopolitically complex geographical space. This historical event was an important moment in decision was aimed precisely at weakening the position of Britain in the region and increasing its influence in the Near Middle East. However, despite this official recognition, Azerbaijan did not establish direct official relations with Israel. The issue to be considered here was not the unwillingness of the Azerbaijani SSR to establish this relationship, but the lack of any legal, political, or sovereign right to do so. Within the framework of the Soviet political system, the union republics were not considered foreign policy subjects, and all decisions in the field of international relations were made centrally by official Moscow. For this reason, Azerbaijan remained only in the position of a passive observer in the process of the creation and recognition of the state of Israel, deprived of the opportunity to pursue a separate

diplomatic line in accordance with its national interests. The relations of the state of Israel, which declared its independence, with the United States and Western countries caused deep concern in the leadership of the USSR, and the state of Israel began to be evaluated as an ally of the capitalist world in the Soviet discourse. This process reached its culmination after the Six-Day War in 1967, which ended with the severance of diplomatic relations between the two sides. Many Jews in the Soviet Union felt a high sense of pride and patriotism after Israel's victory in the Third Arab–Israeli War, often known as the Six-Day War, which took place from July 5–10. Immigration requests to Israel were increasing During this period Jewish movement began to develop in Azerbaijan too. The leader of the protesters in Baku S. M. Kushnir (Asadov, 2023, p. 73). At that time, the right to free migration did not exist in the USSR. Exit from the USSR, especially to Israel, which was considered hostile for geopolitical reasons at that time, was severely restricted by the Soviet aauthorities. That is why uprisings began in many regions of the USSR regarding the increase in immigration quotas, and the USSR was severely condemned by representatives of the international community. In this context, the concept of increasing immigration quotas meant taking practical measures to soften the special permit system in the Soviet context. The state, however, annually imposed certain limits on exit to Israel and other third countries, and these quotas were under the control of state security services. Even the Soviet leadership put forward a number of fabricated arguments to prevent immigration. Due to the rupture in Soviet-Israeli diplomatic relations resulting from this war, the Mountain Jews in the Soviet Union were prevented from immigrating to the state of Israel. Although the obstacles were political, it was accepted that the Mountain Jews were not ethnically Jewish. Those who defended this view in later years defined their arguments as follows:

The Mountain Jews are Persian-speaking.
Except for some terms related to Jewish rituals, the claim is that Hebrew words in their own languages are incomplete.
The religious life of the Mountain Jews is in many cases far removed from the commandments of the Mishnah and Talmud.
Physical similarities between Mountain Jews and other Tat peoples (Osmanlı & Güç, 2020, p. 64).

However, as these actions of the USSR were regularly brought to the agenda in international conferences and the press of both Western countries and the United Nations, the USSR did not change its policy, but it did soften it somewhat. If in 1970 only one thousand people left the USSR on Israeli visas, then in 1971 – already about 13 thousand, in 1972 more than 31 thousand, and in 1973-over 34 thousand people. Subsequently, the number of leave visas declined, and less than 21,000 Jews and their families fled the USSR in 1974. In 1975–1977, even fewer people left every year, from 13 to 16 thousand people. The next three years saw a new increase, and in 1979 the peak of Jewish emigration of the 1970s was noted: more than 51 thousand left. Then, once again, significant limits were imposed on this emigration (Asadov, 2023, p. 73). According to the 1926 census, there were nineteen thousand European Jews and 7.5 thousand Mountain Jews in the Azerbaijan SSR; according to the 1959 census, there were 40,204 Jews (1.1% of the total population of the republic) living in the country, of which 38,917 lived in cities. 8,357 Jews spoke Judeo-Tat as their native language, and 6,255 spoke Yiddish. According to 1970 data, there were 41,288 Jews in the Azerbaijan SSR. According to the 1979 lived in cities. 8,357 Jews spoke Judeo-Tat as their native language, and 6,2 uhh h hear55 spoke Yiddish. According to 1970 data, there were 41,288 Jews in the Azerbaijan SSR. According to the 1979 census, there were 35.5 thousand Jews living in Azerbaijan, and according to the 1989 census, there were 30.8 thousand Jews (Azerbaijan Jews, 2004). Over the past period, this process has affected not only Jews but also representatives of other peoples in Azerbaijan. These indicators are illustrated in Figure 1.

İnzibati ərazi bölgüsü, əhalinin sayı və tərkibi
Administrative territorial divisions, number and structure of population

1.11. Əhalinin milli tərkibi [1)]
(əhalinin siyahıyaalınmalarının məlumatlarına əsasən)
Population by ethnic groups [1)]
(based on population censuses)

Milli tərkib	1926	1939	1959	1970	1979	1989	1999	2009	*Ethnic groups*
	min nəfər thsd. person								
Əhalinin sayı - cəmi	2314,6	3205,2	3697,7	5117,1	6026,5	7021,2	7953,4	8922,4	*Number of population - total*
o cümlədən:									*including:*
azərbaycanlılar	1438,0	1870,5	2494,4	3776,8	4708,8	5805,0	7205,5	8172,8	*azerbaijanians*
ləzgilər	37,3	111,7	98,2	137,3	158,1	171,4	178,0	180,3	*lezgis*
ermənilər	282,0	388,0	442,1	483,5	475,5	390,5	120,7	120,3	*armenians*
ruslar	220,5	528,3	501,3	510,1	475,3	392,3	141,7	119,3	*russians*
talışlar	77,3	87,5	0,1	…	…	21,2	76,8	112,0	*talyshs*
avarlar	19,1	15,7	17,3	30,7	36,0	44,1	50,9	49,8	*avars*
türklər	…	…	0,2	8,5	7,9	17,7	43,4	38,0	*turkishs*
tatarlar	9,9	27,6	29,6	31,8	31,4	28,6	30,0	25,9	*tatarians*
tatlar	…	…	5,9	7,8	8,9	10,2	10,9	25,2	*tats*
ukraynalılar	18,2	23,6	25,8	29,2	26,4	32,3	29,0	21,5	*ukrainians*
saxurlar	15,6	…	2,9	6,2	8,5	13,3	15,9	12,3	*sakhurs*
gürcülər	9,5	10,2	9,5	13,6	11,4	14,2	14,9	9,9	*georgians*
yəhudilər	30,9	41,2	40,2	41,3	35,5	30,8	8,9	9,1	*jews*
kürdlər	41,2	6,0	1,5	5,5	5,7	12,2	13,1	6,1	*kurds*
qrızlar	…	…	…	…	…	…	…	4,4	*kryzs*
udinlər	2,4	…	3,2	5,5	5,8	6,1	4,1	3,8	*udins*
xınalıqlar	…	…	…	…	…	…	…	2,2	*khynalygs*
digər millətlər	112,7	94,9	25,5	29,3	31,3	31,3	9,6	9,5	*other nationalities*

Figure 1
Administrative territorial divisions, number and structure of population

Source: State Statistical Committee of the Republic of Azerbaijan, Population of Azerbaijan, 2021 (Baku, 2022), 21.

Despite all this, Jewish communities still lived in Azerbaijan, especially in the northern regions, in the cities of Guba and Oghuz. From the mid-1980s, a new situation began to emerge in the USSR. M. S. Gorbachev, who became the General Secretary of the CPSU Central Committee, announced a program of political and economic reforms under the name of "openness", "democratization" and "perestroika" at the April plenum of the CPSU Central Committee in February 1986 in order to carry out fundamental reforms in the Soviet economic and political system. This changed the situation in the country. Jews who wanted to emigrate were sent to Israel in groups from 1988 on the initiative of the SOXNUT organization. Jews also began to emigrate in Azerbaijan. These were the first Jews who once settled in Azerbaijan in the form of societies. They began to establish their societies. Thus, in 1990, the Azerbaijan–Israel Friendship Society was established on the initiative of the chairman of the European Jewish community, the famous lawyer M. Khaykin (Məmmədova, 2022, p. 21).

"The Azerbaijan–Israel Friendship Society maintained contact with all officially established Jewish societies in Azerbaijan. Thus, 12 Jewish societies were officially established in Azerbaijan. These

societies operated in accordance with the interests of the Azerbaijan–Israel Friendship Society. These societies were the following:

- Mountain, European and Baku Synagogues;
- Mountain Jews Society in Guba;
- Azerbaijan Jewish Women's Organization;
- Machgavi Sports Club;
- ALEF Youth Jewish Club;
- Club 22 in Sumgayit city;
- Council of Jews Who Participated in World War II;
- Azerbaijan Jewish Trade Union;
- Jewish Cultural Association;
- Karchakov Union (Məmmədova, 2022, pp. 25–26).

1.3 Geopolitical changes in political relations in the first years of independence, a phase of new opportunities

The deep political, economic and social crisis observed in the Soviet Union since the late 1980s, the weakening of central power and the instability in governance ultimately culminated in the disintegration of the USSR in December 1991 and the declaration of independence by 15 of its constituent republics. One of these states was Azerbaijan, located in the Caucasus region. After the restoration of Azerbaijan's independence, a new stage began in state-religious relations, long-term bans on religious activity were lifted, freedom of religion and conscience was ensured, conditions were created for the activities of religious organizations and the performance of religious rites, and international law was followed in the adoption of legislative acts. The rights and freedoms of national minorities and ethnic groups living in Azerbaijan, where multiculturalism is part of state policy, are protected by the articles of the Constitution, and other normative legal acts. In general, all these actions of the state have significantly affected the lives of Jews who decided to choose this state as their homeland after the Azerbaijan gained independence, and especially. Those Jews who are actively involved in the religious organizations of Jews of Azerbaijan (Asadov, 2023, p. 75). All these provisions are reflected in Articles 24, 25, 44, 45 and 48 of the Constitution of the Republic of Azerbaijan. Jews living in Azerbaijan also played a role in the relations between the two countries. After gaining independence in 1991, Azerbaijan emerged as one of Israel's closest friends in the Muslim world. Furthermore, Azerbaijan arose as the key pillar of Israeli cooperation in the South Caucasus and the geopolitical isthmus which allowed for the realization of the vision of a new Turkic world commonwealth that would prevent the Iranian penetration of Central Asia. Since its establishment, Israel always sought allies among Muslim nations, in order to buttress its international legitimacy and to dilute the religious dimension in the Arab-Israeli conflict. After the collapse of the Soviet Union, Israel's foreign policy options expanded. Israel made a decision to engage in deeper relationships with the Commonwealth of Independent States (CIS) countries, in particular with Azerbaijan (Murinson, 2014, p. 9). Many states began to recognize Azerbaijan, which had just regained its independence after 70 years of Soviet dependence, both de facto and de jure. On December 25, 1991, Israel was officially recognized Independence of Azerbaijan, diplomatic relations with Azerbaijan were established on April 7, 1992 (Mammadova, 2023, p. 129).

The State of Israel, founded in 1948, officially established diplomatic relations with Azerbaijan exactly 44 years later. This historical event was the initial stage in the formation of Azerbaijani–Israeli relations in the 21st century. The reason that delayed the establishment of diplomatic relations between the two countries was precisely the foreign policy pursued by Ayaz Mutallibov (1990-1992), who held the post of president at that time, against Russia and Iran. Relations with Israel remained distant in the initial period. Ayaz Mutallibov resigned from his post in 1992 during a difficult political

period and was temporarily replaced by Yagub Mammadov. It was during his time that the first diplomatic relations between Azerbaijan and Israel were established. This step was of historical importance, despite the political instability at that time.

Nevertheless, Azerbaijan decided to recognize the State of Israel only seven months later, thus becoming the third Muslim country after Turkey (1949) and Egypt (1979) to establish relations with Israel (Mruk & Piwowarska, 2021, p. 37). Israel's arms sales to Azerbaijan and support for the Nagorno-Karabakh conflict since the early 1990s, before Azerbaijan declared its independence, paved the way for the expansion of relations between the two countries. These years can be considered the beginning of the Azerbaijan–Israel Strategic Partnership. Building diplomatic relations with independent Azerbaijan was an opportunity for Israel to improve its image in the countries of the region, where Israel's regional legitimacy has historically been contested. Moreover, recognizing Azerbaijan's independence seemed to the Israeli aauthorities to be a step towards improving its position in the United Nations as a state that, while in conflict with Arab countries, can maintain proper relations with another Islamic country and to establish cooperation with new entities in international relations to facilitate Jewish immigration to Israel (Mruk & Piwowarska, 2021, p. 37). That is why Israeli officials have had many official visits and meetings with the Republic of Azerbaijan develop these relations to a higher level. In particular, during the visit of Israeli Ambassador and UN Ambassador Aryeh Levin to Azerbaijan in 1992, the issue of opening an embassy of the State of Israel in the Republic of Azerbaijan was raised. In spite of this, Azerbaijan–Israel strategic cooperation grows step by step. The Azerbaijani government does have an unofficial representative, AZAL (Azerbaijan National Airline), in Israel. In addition to AZAL, the newly opened bureau of Lider TV Channel unofficially represents the Azerbaijani government in Israel. It was the first time for an Azerbaijani television network to send a permanent correspondent to report from Israel and send reports from Israel and other Middle East states to the Azerbaijani audience (Abilov, 2009, p. 151).

In 1992, at a meeting held by the Azerbaijan–Israel Friendship Association in Haifa, Israel, it was requested that Israel support Azerbaijan in the Azerbaijan-Armenia conflict. Azerbaijani statesmen held various contacts in Israel in September 1992. The close relations that Azerbaijan developed with Israel and the influence of the Jewish lobby made it easier for it to gain support from political circles in the United States. This situation made it possible to limit the impact of negative political initiatives carried out by the Armenian lobby against Azerbaijan (Durmuş & Mahmudlu, 2025, p. 64). In February 1993, the former President of the Republic of Azerbaijan, Abulfaz Elchibey, received Haim Barlev, the Ambassador Extraordinary and Plenipotentiary of the State of Israel to Russia. The prospects for cooperation between Azerbaijan and Israel were discussed at the reception, and it was noted that there are wide opportunities for expanding relations in the political, trade-economic, especially agricultural, cultural and humanitarian, medical and scientific spheres. The issue of establishing interparliamentary relations and opening embassies between the two states was also discussed. On the same day, the Israeli Ambassador also held a number of meetings in the Cabinet of Ministers of the Republic of Azerbaijan. During the discussions, the parties exchanged views on the resolution of the Nagorno-Karabakh conflict, which arose as a result of Armenia's aggression against Azerbaijan, and on the migration problem. The Israeli side was interested in establishing and developing bilateral and multilateral cooperation with Azerbaijan. However, these were only the first steps. Abulfaz Elchibey's position on Israel was that Azerbaijan should evaluate Israel not through an ideological or religious prism, but within the framework of national interests and pragmatic foreign policy. He saw Israel as a potential partner for Azerbaijan, but emphasized the importance of conducting these relations in a balanced manner so as not to create hostility with other regional states. According to Elchibey, cooperation with Israel could strengthen Azerbaijan's international position on the path to independence, but this cooperation should be based on state interests, not emotional closeness (Axar.az, 2025). Scholars usually divide Azerbaijan's history into three main periods: the post-Soviet period from 1991 to 1993, when Heydar Aliyev rose to power, the period from 1994 to

2003, and a third that began in 2003 with the rise to power of Heydar's son, Ilham Aliyev. The first three decades of foreign policy, from 1992 to 2010, were characterized by Azerbaijan's tendency toward a realist balancing strategy to secure its national independence (Traub et al., 2024, pp. 2–3). When analyzing Abulfaz Elchibey's speeches during his presidency and his negotiations with the Israeli side, he positively assessed Azerbaijani–Israeli relations. However, the opening of Azerbaijan's diplomatic representation in Israel is explained by a number of historical, political and geopolitical factors. Because the internal situation in the country was not stable, the country that had just gained independence was at war with Armenia. In the tense phase of the Karabakh conflict, the main priority of the state was the protection of the physical and political existence of the state. The second factor to be taken into account was Elchibey's ideological orientation towards Turkey, integration with the Turkic world and exit from the sphere of influence of Russia. In terms of geopolitical and regional balance, the Iranian factor should have been taken into account, because Azerbaijan faced additional risks in its relations with Iran due to both geographical proximity and ethnic factors. Although initial diplomatic contacts and relations with Israel were established during the reigns of both Ayaz Mutallibov and Abulfaz Elchibey, current geopolitical realities prevented these relations from reaching a deeper and institutional level. From 1991 to August 1993, Azerbaijani–Israeli relations were limited and uninstitutionalized, and during this period, it was not possible to establish full diplomatic relations and mutually open embassies. The turnaround in mutual relations between the two countries occurred precisely after Heydar Aliyev came to power. An Israeli embassy was opened in Baku in 1993. While Azerbaijan declined to open a diplomatic mission in Israel, the Azerbaijani aauthorities would always explain this diplomatic imbalance by referring to political constraints Azerbaijan pointed out "its complicated geopolitical situation, particularly its proximity to Iran, as well as its membership in international Islamic organizations (such as the Organization of Islamic Cooperation), as the reason preventing it from opening a mission in Israel. Israel demonstrated understanding to Azeri sensitivities, while pursuing multi-level cooperation with this Muslim republic, including security, military procurement, energy, telecommunications, medicine, trade, education and culture. Israel hoped that Azerbaijan would eventually change their position on this matter (Murinson, 2014, p. 14).

Azerbaijan pursues a foreign policy aimed at moving beyond its close-neighborly relations and gaining strategically relevant allies that can help the country strengthen its position in the South Caucasus and reduce the influence of regional powers such as Russia and Iran. Since gaining independence, Azerbaijan has been open to expanding its network of partners and gathering support for the restoration of the country's territorial integrity. One such ally was Israel. After the opening of the Israeli embassy in Baku, Heydar Aliyev sent Deputy Foreign Minister Vafa Guluzadeh to Tel Aviv with special assignments. The current state and prospects of Azerbaijani–Israeli relations were widely discussed at the meetings. However, there were some factors that prevented the opening of the Azerbaijani embassy in Israel. V. Guluzadeh said in an interview about the importance of bilateral relations and the difficulties: This state supports Azerbaijan on certain issues in international organizations. However, Azerbaijan is a young state, and the opening of each embassy requires a lot of resources (in financial and technical terms (Quluzadə, 1999, p. 233). Vafa Guluzade's negotiations with Israeli officials were carried out within the framework of the basic principles of Heydar Aliyev's foreign policy course. In this context, Aliyev defined the main directions of the country's foreign policy as:

- Protection of the country's integrity;
- Ensuring and protecting economic and political sovereignty;
- Determining and protecting national interests;
- Ensuring the rights and freedoms of citizens;
- Determining the countries necessary for the protection of Azerbaijan's interests and establishing close relations;
- Carrying out a balanced and reciprocal foreign policy with other countries (Yılmaz, 2010, p. 77).

It was after the official diplomatic mission of Israel in Azerbaijan began its activities that dialogues between the two countries expanded. During these meetings, cooperation in certain areas was already on the agenda. Bilateral meetings continued in 1995. On January 28, 1995, Heydar Aliyev met with Shimon Peres, Minister of Foreign Affairs of the State of Israel, while attending the World Economic Forum in Switzerland. The meeting was an important step towards the development of relations between the two countries. During the conversation, it was emphasized that there is great potential for the development of Azerbaijani–Israeli relations in the fields of economy and technology. Both sides noted that there are many opportunities for expanding cooperation between Azerbaijan And Israel in the fields of technology, agriculture, industry and medical services. Shimon Peres stressed that they were looking forward to the visit of the President of the Republic of Azerbaijan Heydar Aliyev to Israel. The Azerbaijani head of state said that he would appreciate this invitation. Although the meeting held in Davos was the first meeting held at a high level between these two states, it showed that mutual relations are at a good level and have great potential (Məmmədova, 2022, p. 35). Azerbaijan's application of certain political limits in relations with Israel from time to time was a result of a forced balancing strategy. Because even though Azerbaijan signed a ceasefire agreement with Armenia on May 8, 1994, the political leadership understood that this conflict would remain frozen. Also, Azerbaijan's international political and lobbying opportunities were extremely limited. Compared to Armenia's powerful diaspora, Azerbaijan was in an asymmetrical position. From this point of view, Israel was instrumental for Azerbaijan in this matter. At that moment, Azerbaijan could not draw a line under relations with Israel, according to the power actors in the region. Taking advantage of the lack of existing alternatives, Azerbaijan kept relations with Israel as a strategic reserve.

Results

In this context, one of the main issues that worries Armenia regarding Azerbaijani–Israeli relations is the influence of the Jewish lobby. The Azerbaijani leadership considers Jews who emigrated from Azerbaijan to Israel to be connected to Azerbaijan and calls them the Azerbaijani diaspora. It is no coincidence that the Jewish lobby in the United States played a major role in the suspension of the famous "Amendment 907" adopted by the US Congress. In November 1998, the leaders of Jewish religious communities operating in Azerbaijan visited the United States, brought to the attention of the facts regarding Azerbaijan during the visit, and justified to the American public and influential Jewish organizations that "Amendment 907" was a wrong decision. They called on these organizations to protect their interests. Progress in this direction was based on the joint efforts of both countries (Azadgil, 2023, p. 39). This success was the result of pragmatic and silent cooperation with Israel. This case study fully demonstrates strategic diplomacy of precaution, which is one of the characteristic features of Azerbaijani foreign policy. Official Baku has neither elevated these relations to an extreme ideological level, nor has it completely abandoned these relations, taking into account the regional sensitivity in the region. On the contrary, it has preserved these relations as an adequate political tool in specific situations.

2. Deepening of Azerbaijani–Israeli relations in the geopolitical and economic context during the Ilham Aliyev era

A new political figure came to power in Azerbaijan after winning a high percentage of the vote in the presidential elections held in October 2003. Ilham Aliyev's coming to power in 2003 was not only the basis for a new beginning in the country's domestic politics, but also the beginning of a new historical era in the foreign policy arena. In this context, the head of state had a number of important issues that needed to be resolved;

- Restoring Security and Territorial Integrity

The main priority is the return of lands lost during the Karabakh conflict in the 1990s. In this context, the importance of Israel as a reliable partner emerges. Azerbaijan, choosing the path of technological modernization and military armament, cooperates closely with the state of Israel in this area.

- Maintaining a Balanced Foreign Policy Course

The main task facing the head of government in a sensitive geopolitical historical period was to maintain the balance of power with the dangerous regional powers in the region – the Islamic Republic of Iran and the Russian Federation. It was during this period that the maintenance and development of relations, especially with Israel, was carried out in a phased manner. Azerbaijan, while maintaining the balance in the region, preferred pragmatic and functional partnership rather than an open alliance.

- Energy Security and Expanding Economic Interests

Bringing Azerbaijani energy resources to international markets and thereby establishing long-term relationships with strategic partners. Considering that Azerbaijan provides more than 40% of Israel's energy reserves, this aspect has transformed from a difference between the two states into a strategic partnership and has reached the political level.

- Strengthening International Positions and Lobbying Opportunities

In the context of the conflict with Armenia, Azerbaijan had little lobbying opportunities and political support in the international arena. It was in this aspect that relations with Israel filled this gap for Azerbaijan and received political support from Israeli lobbies in the USA and many European countries. It was during this period that Azerbaijan intensified its cooperation with strategic partners across the economic, political, technological, and military sectors. Among these countries, Israel emerged as a key partner. When analyzing relations between Israel and Azerbaijan, attention should also be paid to economic cooperation, as one of the most important aspects of bilateral ties, especially in the context of Israel's energy security. Israel is one of Baku's five key trading partners (Sattarov, 2017, p. 45). It should also be noted that the official working visit between the two countries played an undeniable role in establishing these relations. Israeli Foreign Minister Tzipi Livni, while giving an interview to the Azerbaijani Today, Az. News Agency on December 25, 2008, clarified the question of why the Azerbaijani embassy in Israel has not yet been opened and expressed the following thoughts: Even though the Azerbaijani embassy in Israel has not been opened, cooperation between Azerbaijan and Israel in the economic and cultural fields is developing at a high level (Məmmədova, 2022, p. 76).

In response to their commitment to act on behalf of Azerbaijan, Foreign Minister Elmar Mammadyarov asserted that "American Jews have helped us lobby in Washington against the Armenians and their help is very important. We are very appreciative. In fact, relations between the two countries have become so close that according to Foreign Minister Lieberman, Azerbaijan could become a mediator between Israel and the Arab world (Ismayilov, 2013, p. 71).

The logical and political conclusion of diplomatic and political relations between the two countries was reached with the official visit of the President of the State of Israel, Shimon Peres, to Azerbaijan on June 28-29, 2009. The delegation included a number of ministers, government representatives, and businessmen. This indicated that the visit had a rich program and was aimed at deepening mutual relations in a number of areas. In the exclusive interview granted to the Azerbaijani news agency Trend News, Peres said: A lot of things unite us... Azerbaijan manifested tolerance and respect for that place where Jews, Muslims, and Christians can live without hatred and fanaticism. That is why [Azerbaijan] is, for me, a special country that I can trust (Murinson, 2014, p. 16). Peres also

emphasized the Israeli leadership's desire to share technological and scientific assets with Azerbaijan. He continued his interview by saying that: "Israel does not possess significant territory, water, natural gas, or petroleum. That is why we. have to rely on our brainpower and our science. We must share everything we possess with Azerbaijan in areas of mutual interest (Trend News Agency, 2009).

The issues discussed coincided with the interests of both sides. The Palestine-Israeli and Armenia-Azerbaijani conflicts were also discussed during the meeting, and both sides stated that they are working towards a peaceful resolution of the conflict. In particular, the contacts and meetings that began between Azerbaijani and Israeli government representatives since 2003 opened a new page in relations with the visit of the Israeli President to Azerbaijan in 2009. The next stage of cooperation began in the military and economic spheres.

One of the important factors influencing the relations between Israel and Azerbaijan is undoubtedly Azerbaijan's abundant energy resources, especially oil fields. The Baku-Tbilisi-Ceyhan (BTC) oil pipeline project, whose construction began in 2002, began operating in 2005 and facilitated Azerbaijan's access to the international energy market. In July 2007, the first bilateral investment protection agreement was signed between Azerbaijan and Israel. The agreement emphasized the strengthening of economic ties between the two nations. As noted in the agreement, Azerbaijan's exports to Israel covered a range of goods, reflecting the growing trade partnership. These indicators are illustrated in Figure 2 and 3.

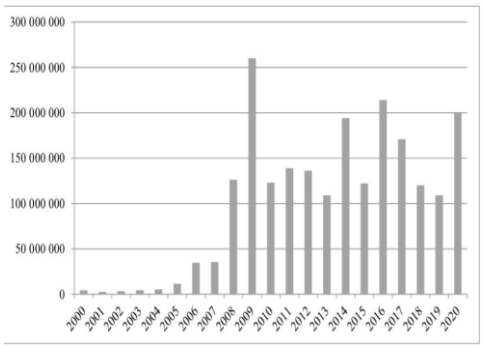

Figure 2
Valueof exports from Azerbaijan to Israel in 2000-2020

Source: Marzena Mruk and Sara Piwowarska, "Israel and Azerbaijan in the 21st Century – Sincere Cooperation or a Marriage of Convenience? Outline of the Issues," Nowa Polityka Wschodnia, no. 4 (31) (2021): 41.

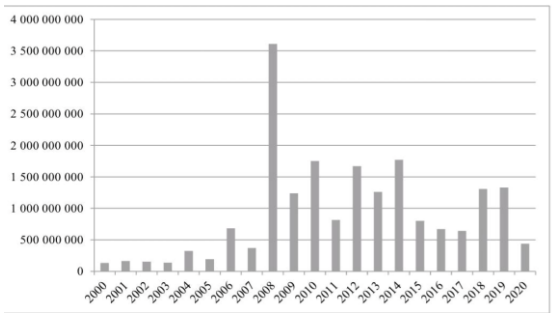

Figure 3
Value of goods exports from Israel to Azerbaijan in 2000-2020

Source: Mruk and Piwowarska, "Israel and Azerbaijan in the 21st Century," 41

Between 2000 and 2005, Israel's position among Azerbaijan's trading partners changed significantly. Statistical indicators clearly show that during this period, Israel rose from 10th to fifth place among Azerbaijan's main trading partners. This dynamic indicates the intensification of economic relations and an increase in trade volume between the two countries. Thus, in2008, the value of oil and oil products imported by Israel from Azerbaijan exceeded 3.5 billoon (Hasanov, 2025, p. 174). These graphs clearly explain the economic, political, and strategic anatomy of the Azerbaijani and Israeli positives. Due to its difficult geopolitical position, Israel sees Azerbaijan as its energy supplier to meet its energy needs. Israel views crude oil as a matter of Azerbaijan's exports to Israel. Therefore, this trade is not a normal economic, but a strategic energy relationship. Another nuance that attracts attention in the table is the increase in exports from Azerbaijan to Israel in 2007-2009 compared to 2000-2006. The reason for this is that the diplomatic base between the two countries was not fully strengthened in 2000-2006 and trade turnover had not yet reached the strategic project stage. The increase in exports in 2007-2009 coincides with 3 processes;

1. The BTC oil pipeline begins to operate at full capacity.
2. The search for alternative and secure energy sources against the backdrop of Israel's conflicts with its neighbors and the IRI.
3. Azerbaijan's transition to an institutional and open stage in relations with Israel since 2007.

In an interview with the Azeri News agency APA, Israeli former Ambassador Arthur Lenk said that, Israel is Azerbaijan's second largest partner in the business field on April 29, 2009. Israel purchases oil from Azerbaijan and it assumes great importance for us. According to the outcomes of 2008, the commodity turnover between the two countries totals $180 million, but we don't want to be satisfied with this figure. We are eager to have more business. The Ambassador also stressed that we will try to increase the trade turnover between Azerbaijan and Israel, which in January-March 2009 reached $180 millions (Abilov, 2009, p. 157). In 2009, these exports peaked at approximately $260 million. This is a clear example of the reflection of geopolitical decisions on the chart, not just market ones. According to the third figure the products exported from Israel to Azerbaijan were not consumer goods, they were mainly military technologies, unmanned aerial vehicles (UAVs), radar and surveillance systems, anti-aircraft missile systems, communication technologies, etc.

One of the areas where Azerbaijan closely cooperates with Israel is the military industry. Israel plays a crucial role as a supplier of various types of military equipment and technologies to Azerbaijan. During the First Nagorno-Karabakh Conflict, Israel's support for Azerbaijan, both politically and technically, played a significant role in the development of relations between the two countries. During visits by Israeli officials to Azerbaijan, the Armenia-Azerbaijan conflict and the issue of Azerbaijan's territorial integrity were widely discussed. In particular, the occupation of more than 20% of Azerbaijan's territory by Armenia drew global attention to the region's security and stability challenges (Hasanov, 2025, p. 174).

The statistics in the figure show that the total value of products exported from Israel to Azerbaijan during the years 2000-2004 did not even reach $1 billion. There are several reasons for this;

1. The Azerbaijani Armed Forces have not yet fully emerged from the post-Soviet structure.
2. The main countries in terms of arms supply are Russia, Ukraine, Belarus.
3. Israel has not yet formed Azerbaijan as an alternative military-technological partner.
4. Economic restrictions and oil revenues have not yet been formed.

Statistics show that the rapid growth that began in 2005-2007 reached its peak in 2008-2009, when more than $3.6 billion worth of equipment was exported from Israel to Azerbaijan. This means that one or more mega contracts were signed. Because the relations between the two countries had moved to a qualitatively different stage at that time. This was due to the visit of Shimon Peres, the Minister

and then President of the State of Israel, to Azerbaijan in 2008-2009, and the cooperation achieved in many areas. In this regard, the two sides do not see each other as mere trade partners, but as strategic partners that reduce risks.

In the economic sphere, Israel has been among Azerbaijan's top five trade partners for most of the post-Soviet period. Azerbaijan is Israel's top oil supplier, delivering both crude and refined products, and providing around 30-40 percent of Israel's annual consumption, depending on the year. Israeli imports represent approximately 10 percent of Azerbaijan's oil exports. The oil trade between Azerbaijan and Israel takes place via direct sales from SOCAR to Israeli refineries and via European oil traders (Idan & Shaffer, 2021, p. 192). The level of cooperation between Azerbaijan and Israel is considerable. In 2015, Baku-Tel Aviv trade was valued at $5 billion, exceeding that between France and Israel. (Omidi & Kheiri, 2018, p. 35) Azerbaijan's dire need for modern technology, economic progress, and foreign investment, well as the region's limited infrastructure, has led Azerbaijani officials to cultivate relations with Israel and bolster the country's economy. The vast reserves of energy in Azerbaijan's shores, which are about 7 billion crude oil barrels and 35 trillion cubic feet of natural gas, have turned the country into a considerable actor in the market for energy (Ebrahimi & Quli, 2023, p. 27). The close cooperation between these two states in the economic and commercial sphere was undoubtedly due to the rich energy resources of Azerbaijan, and Israel, in turn, has modern equipment in the energy sector. The formation and development of cooperation between the two countries in the energy sector covers the years 1999-2014.

It was during these years that the foundations of cooperation in the energy, trade, and military fields were laid and memorandums and agreements were signed with regular meetings of state officials of both sides. In 2005, Azerbaijani Deputy Foreign Minister Araz Azimov visited Israel, and in 2007, Israeli Deputy Prime Minister and Minister of Strategic Affairs Avigdor Lieberman visited Baku, demonstrating the parties' desire to develop relations. In addition, in 2007, Israel even held a ceremony in the Knesset to celebrate Republic Day and show its value to Azerbaijan. During this process, Azerbaijani bureaucrats thought: "Israel, a Jewish state, may be seen as a threat by Muslim states, but with its secular, democratic, Western image and strong military structure, it is becoming an option for Azerbaijan (Cankara & Cankara, 2022, p. 5).

In addition, it should be taken into account that the development of cooperation in the energy sector was in part also connected with BTC. Because this belt diverted Azerbaijani oil away from the Russian and Iranian routes. Therefore, this belt created the logistical and geopolitical basis of energy cooperation. On June 5, 2005, during the opening of the 14th "Caspian Oil and Gas Exhibition" in Baku, former Israeli Ambassador Arthur Lenk spoke about cooperation in the energy sector between . the two countries and even noted the importance of the BTC oil pipeline during his speech at the exhibition. During his interview with the Azerbaijani news agency APA, Mr. Ambassador said: The main thing is that Israel buys Azerbaijan's oil through the Baku-Tbilisi-Ceyhan pipeline. Israel and Azerbaijan have close political and economic relations. Interstate relations are also strengthening and the ministries of the two countries pay mutual visits (Abilov, 2009, p. 155). Energy security is an important part of this bilateral relationship due to Azerbaijan's vast energy resources and its geographic position. On July 6, 2006, at the opening ceremony of the BTC in the Mediterranean port of Turkey, Minister of National Infrastructure Ben Eliezer stated in his speech that the main export oil pipeline is an important factor in Israel's energy policy towards Azerbaijan. Israel was officially one of the 36 participating representatives at the ceremony. Later, the Israeli side proposed extending the BTC main export oil pipeline to the Red Sea port of Eilat. The main goal here was to create conditions for transporting Azerbaijani and Central Asian oil to the markets of India, Japan and South Korea via Israel (Abilov, 2009, p. 156). Israel, in turn, has provided Azerbaijan with many modern technological equipment in order not to lose its safe and sustainable energy source. This process began precisely after the first oil was transported to Israel after the opening of the BTC pipeline. Table 3 illustrates the structure of Israel's non-military exports to Azerbaijan.

Table 3
Israeli Non-military Exports to Azerbaijan

Year	Export Volume
2007	$82.5 million
2008	$129.4 million
2009	$250 million
2010	$200 million
2011	$125 million

Source: Alexander Murinson, The Ties between Israel and Azerbaijan (Ramat Gan: The Begin-Sadat Center for Strategic Studies, Bar-Ilan University, 2014), 7.

Statistics demostrates us that Israel-Azerbaijan relations did not start only with the military sphere. We should take into account that in 2002-2010, Israel took 2nd place in Azerbaijan's foreign trade turnover. This is calculated directly with oil exports. We can also see from the statistics that exports worth 82.5 million US dollars in 2007 reached 129.4 million US dollars in 2008. This was a 57% increase compared to the previous year alone. The growth trend increased further in 2009 and reached its peak, reaching 250 million US dollars. Thus, exports increased more than 3 times in two years, the total volume was 167.5 million dollars. This was a total increase of 203% compared to 2007. In 2010, the export volume fell to 200 million dollars, which was a 20% decrease compared to the previous year. The decline dynamics were also noticeable in 2011, this time the decrease was

37.5% compared to the previous year. However, it should be taken into account that this decline was not a collapse, but a gradual one. Nevertheless, the export balance between the two countries was maintained in the following years. The reason for this is that the main implementation phase of large-scale technological and infrastructure projects has been completed, and military equipment has already begun to be sent to Israel for security reasons in the following years. In general, it is clear from the statistics that the total export expenditure for the five-year period 2007-2011 was 786.9 million US dollars.

2.1. The role of Israeli technologies in the modernization of the Azerbaijani Armed Forces

One of the issues discussed in the relations between the two states was the peaceful resolution of the Nagorno-Karabakh conflict, which was created as a result of Armenia's military aggression and occupation of Azerbaijan, and the situation of Azerbaijani refugees and internally displaced persons. The research conducted shows that there was no meeting held at various levels that did not pay attention to the issue related to the Nagorno-Karabakh conflict. Among the countries to which the Azerbaijani side appealed to stop and condemn Armenia's aggression, the State of Israel occupied a special place. Jewish lobbies and organizations also played a certain role in this matter. In January 1994, the Azerbaijan–Israel Friendship Society sent a letter to the Prime Minister of the State of Israel, L. Rabin, and the Minister of Foreign Affairs, Shimon Peres, requesting assistance in achieving peace in the Azerbaijani-Armenian war and the withdrawal of the Armenian army from the occupied 20% of the lands of Azerbaijan. In response to this request, the Israeli side sent 2 tons of medicines and humanitarian aid for use in Azerbaijani hospitals. such attention was both a humanitarian step and one of the factors affecting relations between the two countries (Məmmədova, 2022, p. 82). These issues were always brought up during official and unofficial dialogues with Israeli state representatives during the reigns of both Heydar Aliyev and Ilham Aliyev in order to resolve the Karabakh conflict. One of these dialogues took place during the visit of Israeli Prime Minister Netanyahu to Azerbaijan in August 1997. In the negotiations held, bilateral, regional and international relations were initially on the agenda of the meeting. From 1994 to 2009, the State of Israel expressed its support for the Karabakh conflict only formally. "However, according to some reports, the London-

based newspaper "Al-Wassat" wrote that Israel and Turkey provided Azerbaijan with "Stinger" anti-aircraft missiles during the Nagorno- Karabakh conflict (1991–1993) (Aras, 1998, pp. 73–74). Even many Azerbaijanis expressed the hope that friendship with Israel might help resolve the continued Nagorno-Karabakh dispute and expatiate Azerbaijan's integration with the West. The highest-level meeting held between the parties regarding the Nagorno-Karabakh context was the talks organized on June 28-29, 2009, with the participation of delegations of Israeli President Shimon Peres and Ilham Aliyev, who were on an official visit to Baku. The opinions expressed at the press conference held after the signing ceremony of the documents based on the negotiations and agreements reached showed that the positions of Azerbaijan and Israel on the resolution of regional and international relations are the same. In an interview with Trend news agency, Peres said that Israel supports the territorial integrity of Azerbaijan. This appears to be a clear reference to the Nagorno-Karabakh dispute, in which ethnic Armenians continue to occupy territory within Azerbaijani borders. I know that Azerbaijan has problems around. Basically, the problems stem from your neighbors. Because in politics you cannot choose your neighbors, as in the family you cannot choose your parents. It is a fact of life. Israel is totally for the territorial integrity of Azerbaijan. We don't think that one country can come and annex a part of another land, he said (Trend News Agency, 2009).

The world arms market has become a growing trend. In this market, Israel also exports various weapons technologies and is trying to expand its market network. At this point, in addition to Israel's historical ties to Azerbaijan, Azerbaijan's occupied territories and its border location close to Iran cause it to see it as an indispensable opportunity for arms trade. Between 2010 and 2015, Azerbaijan bought the most weapons from Russia (2008 Russia's interventions in Georgia-Ossetia prompted Azerbaijan to think and make new moves). Azerbaijan, which is looking for better and more reliable weapons than the weapons imported from Russia, has reached the arms market of Israel (Soylu, 2024, p. 26). Thus, in 2011, Azerbaijan signed a military contract worth 1.6 billion dollars to modernize the Azerbaijani armed forces. The delivery of agreed weapons and technologies to Azerbaijan within the framework of military-technical cooperation began in 2012 (Hasanov, 2025, p. 175). In May 2012, Minister of Foreign Affairs Elmar Mammadyarov made an official visit to Israel and met with Prime Minister Netanyahu and President Peres, thus, for the first time in history, the Minister of Foreign Affairs of Azerbaijan went to Israel. Another critical development experienced in 2012 is the sale of weapons including drones, anti-aircraft defense systems and missiles to Azerbaijan by Israel Aerospace Industries in the amount of 1.6 billion dollars. Thus, Azerbaijan attracted the attention of the countries of the region by making approximately 43% of its arms expenditures with Israel this year (Cankara & Cankara, 2022, p. 6). The list of military equipment worth 1.6 million US dollars exported to Azerbaijan under the relevant agreement signed with Israel in 2011 is reflected in Table 4.

Table 4
Azerbaijani arms orders to Israel 2011

Equipment	Quantity	Date	Comments
Barak MX surface-to-air missile system	1	2011	Delivered in 2016 Part of a $1.6 billion contract
Barak ER interceptors	40	2011	Delivered in 2016. For the Barak MX system. Part of a $1.6 billion contract.
Barak LRAD interceptors	40	2011	Delivered in 2016. For the Barak MX system. Part of a $1.6 billion contract
Heron tactical drones	5	2011	Delivered in 2013. Part of a $1.6 billion contract.
Searcher observation drones	5	2011	Delivered in 2013. Part of a $1.6 billion contract.

Source: Stockholm International Peace Research Institute (SIPRI), Arms Transfers Database.

At this point, Azerbaijan's purchase of military equipment from Israel in 2012 was 1.6 billion dollars. In the same year, the Minister of Foreign Affairs of Israel paid a visit to Azerbaijan and during this visit to Baku, he stated that Israel relations with Azerbaijan are more important than relations with France. became acquainted with drone systems. A number of Azerbaijani arms orders from Israel since 2011 are described in Table 5. By 2016, the total value of weapons exported from Israel to Baku exceeded 6 billion dollars (Fars News Agency, 2021).

Table 5
Azerbaijani arms orders to Israel 2013-2019

Equipment	Quantity	Date	Comments
Sandcat AFVs	100	2015	Delivered between 2016-2018
Spike LR guided anti-tank missile system	10	2015	Delivered in 2016. For Sandcat AFVs
Spike LR guided anti-tank missiles	250	2015	Delivered in 2016. For Sandcat AFVs
Orbiter 1K loitering munitions	100	2016	Delivered between 2016-2020. Includes component production and assembly in Azerbaijan
Orbiter-3 tactical drones	10	2016	Delivered between 2016-2017
SkyStriker loitering munitions	250	2016	Delivered between 2018-2020
Hermes-900 tactical drones	2	2017	Delivered in 2017-2018
LORA mobile quasi-ballistic theatre missile system	4	2017	Delivered in 2018
LORA surface to surface missiles	50	2017	Delivered in 2018. For the LORA system
SPEAR 120mm vehicle portable mortar	10	2017	Delivered in 2018. For Sandcats
Spike NLOS surface-to-surface missiles	100	2019	Delivered in 2020.

Source: Stockholm International Peace Research Institute (SIPRI), Arms Transfers Database.

In general, one of the main reasons for Azerbaijan's successes in both the 2016 four-day war and the 44-day Second Karabakh War (2020) is the large-scale increasein military spendingfrom 1995 to 2022, funded by oil industry revenues since 1994. During this period, energy-sector resources significantlycontributedtomodernizing the Azerbaijani armed forces, acquiring advancedmilitary technologies, and enhancing combat readiness (Hasanov, 2025, p. 176). When these indicators are examined comparatively, Figure 4 ("Military Spending: How Azerbaijan Surpassed Armenia") clearly illustrates Azerbaijan's substantial advantage over Armenia in terms of military expenditures.

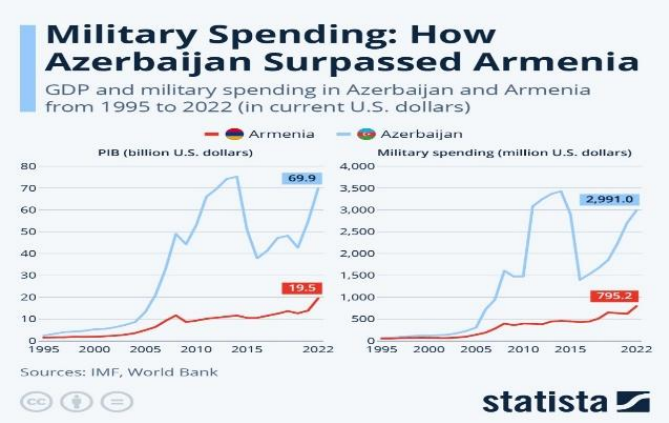

Figure 4
Military Spending: How Azerbaijan Surpassed Armenia

Source: International Monetary Fund (IMF) and World Bank.

According to the graph, Azerbaijan's GDP has improved significantly since 2005. This is already due to Azerbaijan's projects in international oil and oil products in the region. As a result, while Azerbaijan's GDP in 2022 was $69.9 billion, Armenia's was $19.5 billion. When. Looking at the field of military spending, the picture was again heartening for the Azerbaijani side. In particular, the increase that began in the 2000s peaked between 2010 and 2015. Reaching approximately $3.5 billion. While this figure was $2.991 billion in Azerbaijan in 2022, military spending in Armenia amounted to $795.2 million. Thus, Azerbaijan has cooperated with Israel, which has the world's most advanced military technologies, and this cooperation has grown stronger each year (Hasanov, 2025, p. 177).

3. Regional Geopolitical Environment and Reasons for the Late Opening of the Embassy

Notwithstanding, Iran and Azerbaijan are both Shi'i Muslim countries and have a common historical and cultural heritage. History as well as ideological and political factors have shaped relations between the two countries and have influenced the policies of the Islamic Republic of Iran toward the Republic of Azerbaijan, Iran was. Among the first countries to recognize Azerbaijan's return to independence in 1991. Establishing diplomatic relations with Baku in March 22, 1992. Since the Soviet disintegration, however, the unstable and complicated Iranian-Azerbaijani relationship has demonstrated Tehran's discomfort with Azerbaijan's existence as an independent and secular state (Khalifa-Zadeh, 2013, p. 58). Although Iran initially sought to spread the Islamic revolution after the collapse of the USSR, it has replaced this policy with more economic dialogues in modern times. After gaining independence, our country's establishment of relations with the West and Israel, and its adoption of a secular state model, have made it difficult for Iran to influence the Shiite population in Azerbaijan (Keskin, 2008, pp. 50–52). An important event that caused Iran's concern was the establishment of relations between Azerbaijan and Israel on April 7, 1992. Despite the strategic partnership between Azerbaijan and Israel, other factors delayed Azerbaijan's decision to open an official embassy in Israel. One of these factors was Azerbaijan's membership in the OIC. After declaring its independence, Azerbaijan joined this organization in December 1992. The OIC has played a significant role in strengthening Azerbaijan's cooperation with the Arab and Muslim world. Another essential factor to consider was Iran's stance. Iran perceived the diplomatic rapprochement between Azerbaijan and Israel as a potential threat to its national security and regional geopolitical interests. Iran, in turn, put forward many arguments. They claimed that Azerbaijani–Israeli relations and military cooperation were a threat to Iran's national security in the region, they assessed Azerbaijan's relations with Israel as a step contrary to the rights of the Palestinian people, and

considered it against the unity of the muslim world (Hasanov, 2025, pp. 180–181). Iranian political analysts and researchers continue to advance arguments on various platforms and in academic circles about the potential threats posed by Azerbaijan's rapprochement with Israel. For instance, in some Iranian political discourse, Israel is described in delegitimizing terms, and Iranian analysts argue that the Zionist regime, aiming to hinder the IRI's influence in the region, seeks to develop ties with Azerbaijan. As it relates to politics, culture, and economy, Azerbaijan is Iran's sphere of influence. Given the Tehran-Tel Aviv strategic animosity, the Israeli presence and influence in the neighboring countries could threaten Iran's interests and national security; hence, Israel's political, military-intelligence, and economic presence in Azerbaijan poses a considerable threat to Iran's national security in politico-military, financial, and security domains (Sayyar et al., 2023, p. 130) While Israeli foreign policy doctrine has been pursuing partners with common economic and security interests, Iran has remained extremely cautious of such endeavours, perceiving Israel's interest in Azerbaijan to achieve geographical proximity to Iranian territory surreptitiously. The Iranian government believes that Tel Aviv's primary goal in pursuing enhanced cooperation with Baku is to collect intelligence and plan military attacks on Iran from Azerbaijan's territory (Miholjic-Ivkovic, 2023, p. 55).

In response to Iran's concerns regarding this issue, official Baku, in turn, issued a statement to the other side, stating that in the context of relations with Israel, the territory of Azerbaijan cannot, under any circumstances, be used as a military confrontation zone against the territory of a third country. In a situation where the South Caucasus countries are showing political and security orientation towards Israel, the United States and Western European countries, the Islamic Republic of Iran has considered the Russian Federation as a key strategic ally against these influences. In this context, Tehran has openly supported Russia's policy aimed at preventing the political, military and institutional influence of the United States and Western countries in the South Caucasus region. Therefore, we can iden tify Tehran's strategic priorities in the Southern Caucasus as follows:

1. To stop both Georgia and Azerbaijan from moving toward NATO/EU membership:
2. To minimize Israel's influence and cooperation with the South Caucasian countries:
3. To arrange the security system in accordance with Iran's strategic interests;
4. To control the Caspian energy resources and transportation routes;
5. To contain the rising influence of Turkey and the Turkey-Azerbaijani alliance (Khalifa-Zadeh, 2012, pp. 70–71).

Iran is very concerned that Iranian Azeris may establish their own Azerbaijani state, as happened early in 20th century, or join the Republic of Azerbaijan. In this context, the existence of the Republic of Azerbaijan is a strategic factor for Iran's long-term calculations, as well as for the Azeri nation-al-liberation movement in this country. The mallah's regime in Tehran feels extremely uncomforta ble about the possibility of Azerbaijan's secular and successful experience inspiring or igniting the Iranian Azeris to put an end to the mullah's power. Thus Azerbaijan's independence is a strong exacerbating factor for Iran's policymakers. There-fore, Iran's priorities toward Azerbaijan can be identified as follows;

1. To stop Israel's cooperation with Azerbaijan and Georgia;
2. To minimize America's influence and stop Azerbaijan's hid for EU/NATO membership;
3. To damage Azerbaijan's international image.
4. To contain Azerbaijan's rise to regional power,
5. To provide assistance to Azerbaijan's regional rival-Armenia;
6. To maintain the balance between Azerbaijan and Armenia:
7. To keep Azerbaijan engaged in the war with Armenia;
8. To support Russia's "cosmetic" attempts to solve the Nagorno-Karabakh conflict,
9. To keep Azerbaijan under Russia's dominance (Khalifa-Zadeh, 2012, p. 72).

3.1 Opening of Azerbaijan's diplomatic mission in Israel in the context of the Second Nagorno-Karabakh War

After Azerbaijan's absolute victory over Armenia during the Second Karabakh War, the geopolitical balance in the region has changed significantly. The military-political victory achieved in 2020 was a significant turning point not only in terms of the return of 20% of Azerbaijan's occupied territories, but also in terms of expanding Azerbaijan's foreign policy maneuvering possibilities.

In this context, the opening of Azerbaijan's diplomatic mission in Israel has acquired particular importance. It all starts after the liberation of Karabakh, as the liberation of the occupied territories of Azerbaijan by Iran, one of the power actors in the region, raises many concerns in Iran. After the liberation of Karabakh, the concerns that have arisen in the political circles of the Islamic Republic of Iran are in the following areas;

- The possibility of Azerbaijani–Israeli relations entering an open phase
- Turkey's growing influence in the region
- The issue of the Zangezur corridor and transport communications
- Ethnic and internal stability factor
- Iran's declining influence over Armenia
- Expanding Azerbaijan's room for maneuver in foreign policy

It is in this context that Iran once again expressed its concern about the multi-vector policy of the Republic of Azerbaijan. After the second Karabakh conflict, relations with Iran reached their peak compared to previous years. Therefore, the Azerbaijani victory in Karabakh was not welcomed by Iran at all. Because after the second Nagorno-Karabakh War, with Azerbaijan's recapture of its territory, Iran's. 132-km border with Armenia decreased to 40 km. There are many reasons for this unhappy attitude, including regional economic policies and Iran's internal dynamics. The most important of these reasons is the concern that the increase of Azerbaijan's political influence in the region, which we mentioned earlier, will create a psychological environment for the demand for independence by millions of Turks living within the borders of Iran. In addition, if Turkmen gas is connected to Europe via the Zengezur Corridor, the demand for Iranian gas will decrease, and this concern has become very strong in Iran. Iran, which takes a threatening position on all these issues, has repeatedly expressed that it is extremely uncomfortable with the advancement of relations between Azerbaijan and Israel (Soylu, 2024, p. 28). The fact that the 132 km section of the Iran-Azerbaijan border, as a result of the liberation of Karabakh, came under the full control of Baku was not only a geographical change for Iran, but also a decrease in regional influence, a disruption of the transit balance, and an increase in national security risks. Iran's direct border with Azerbaijan has actually expanded. The reduction of Iran's border with Armenia to 40 km has not only reduced Iran's indirect contact opportunities with Armenia, but also weakened its strategy of influencing the region through Armenia. Also, the emergence of the Zangezur corridor on the agenda has left Iran with the danger of losing its transit role in the region and even being left out of these processes. between September 11-21, 2021, the "Three Brothers 2021" exercise was held in Baku between Turkey, Pakistan and Azerbaijan, and this situation seriously disturbed Iran. The military exercise, in which new combat tactics were tested using modern technological products, ensured coordination among the participants, and on the other hand, it intimidated other players in the region in terms of showing the extent of cooperation between them. In response to these developments, Iran conducted a military exercise called "Khyber Conquerors" on October 1 in the northwest of the country, that is, on the border of Azerbaijan and Armenia. Although the Commander of the Iranian Ground Forces, General Kiyumers Heyderi, said that the purpose of the exercise was to increase the capacity of the Iranian soldiers to be present, his statements showed that this was not the only issue. Heyderi stated that the party hindering stability in the Middle East is Israel, that Iran does not have a hot conflict with its

neighbors because it has not had a border change policy for a long time, and that they respect Azerbaijan's territory by not supporting Iran's occupation of Armenia in the Nagorno-Karabakh conflict. On the one hand, Heyderi tried to draw attention to the military exercises conducted around Iran and mentioned that there is an exercise in Turkey as well (Cankara & Cankara, 2022, p. 12).

Official Baku, which is involved in Iran's baseless claims against Azerbaijan, has an official statement in this context based on international law and international norms. This statement is based on both Azerbaijan's own constitution and a number of other internal laws, as well as laws adopted by the international community. According to Article 2, paragraph 4 of the Charter of the United Nations, all member states may not use force against the territorial integrity or political independence of another state. Azerbaijan has also accepted this principle as a member of the UN (March 2, 1992). Another legal act to consider is the Constitution of the Republic of Azerbaijan. Clause 3 of Article 11 of the Constitution of the Republic of Azerbaijan states: The territory of the Republic of Azerbaijan is indivisible; a part of the motherland cannot be given or leased to any state. This provision prohibits the use of Azerbaijan's territory for any military purposes, including against a third country (Constitution of the Republic of Azerbaijan, art. 11, para. 3).

According to Article 151 of the Constitution of Azerbaijan, international agreements take precedence over Azerbaijani legislation. This means that Azerbaijan should act in accordance with the principles adopted by organizations such as the UN and the OSCE (Constitution of the Republic of Azerbaijan, art. 151). The religious aspect is the main factor causing ideological contradictions in Tehran's foreign policy regarding the Armenia-Azerbaijan conflict. Iran's full support for Christian Armenia against Muslim, constitution, which states that Iran's foreign policy is based on protecting the rights of all Muslims, but it is also one of the main obstacles to the development of Azerbaijan-Iran bilateral military-political relations (Aghazada, 2023, p. 722). Article 11 of the Iranian Constitution also states that the Islamic Ummah is considered a single society and that the Islamic Republic of Iran considers ensuring unity and solidarity among all Muslim nations as one of the basic principles of its foreign policy (Constitution of the Islamic Republic of Iran, art. 11). According to this article, religious solidarity and common identity should play a decisive role in the relations of the Iranian state with Muslim countries and peoples. However, Tehran's support for Christian Armenia in the Armenia-Azerbaijan conflict and its position towards Azerbaijan, which has a Muslim and especially Shiite identity, clearly contradict this constitutional principle. At a time when Muslim countries are normalizing relations with Israel, Azerbaijan's southern neighbor has begun to take steps against Iran. During the Azerbaijan-Armenia border clash in September and on the issue of the Zangezur corridor, the statements of Iranian military and political leaders that "Armenia's borders are Iran's red line were not received unambiguously in Azerbaijan. In the future, the opening of an Iranian consulate in the Armenian city of Qafan, located on the border with Azerbaijan, further heightened tensions in relations (Topchubashov Center, 2022). Another unconstructive step by Iran was demonstrated during the attack on the Azerbaijani embassy in Tehran. As the host country, Iran was obligated under the Vienna Convention on Diplomatic Relations to ensure the. of the embassy and the safety of its employees. Article 22 of the Vienna Convention imposes a direct obligation on the receiving state to ensure the inviolability of diplomatic missions and to prevent any threat to the security of theembassy. At the same time, Article 29 of the Convention imposes on the state responsibility to ensure the personal immunity of diplomatic personnel. Iran's failure to fulfill these obligations during the attack on the Azerbaijani embassy was assessed as a gross violation of international diplomatic law (Vienna Convention on Diplomatic Relations, 1961, art. 22).

At the same time, Article 2(4) of the UN Charter prohibits the use of force or the threat of force against states. An attack on a diplomatic mission, in fact, acts as a form of force by one state against the sovereign rights of another state and contradicts this fundamental principle of international law (Charter of the United Nations, 1945). These events clearly show that the principles of friendship and neighborliness officially declared by Iran are not compatible with each other in reality. The attack on

our Azerbaijani consulate in Tehran is a clear indication of Iran's insincere position towards official Baku. The Azerbaijani Foreign Ministry also announced the opening of the embassy. It was reported that on March 29, the opening ceremony of the Embassy of the Republic of Azerbaijan in the State of Israel was held with the participation of Foreign Minister Jeyhun Bayramov and Israeli Foreign Minister Eli Cohen (Qafqazinfo, 2023). The establishment of Azerbaijan's diplomatic mission in Israel marked the beginning of a qualitatively new stage in Azerbaijani–Israeli relations, and bilateral relations were officially elevated to the embassy level.

Conclusion

This article is devoted to a comprehensive analysis of the historical, economic and military-political factors of the establishment of the diplomatic mission of the Republic of Azerbaijan in the State of Israel. The main goal of the research is to examine the stages of formation and development of Azerbaijani–Israeli relations, the factors affecting the delay in the institutionalization of these relations, and finally, the geopolitical realities that conditioned the opening of the embassy in Israel in 2023, within a scientific-theoretical and empirical framework. The first part of the research analyzes the historical-social foundations of Azerbaijani-Jewish relations, the existence of Jewish communities in Azerbaijan since ancient times, the legal and social status of Jews during the Azerbaijan Democratic Republic and the Soviet period. At the same time, the initial stage of Azerbaijani–Israeli relations after independence (1991–1993) and the reasons for the limited nature of diplomatic relations during this period are examined.

The next part of the dissertation analyzes the impact of the Karabakh conflict on Azerbaijani–Israeli relations and the role of the regional geopolitical environment. During the First Karabakh conflict, Azerbaijan's weak international lobbying capabilities and the position of regional power actors, especially Iran and Russia, have been shown to have led to a more pragmatic and "silent cooperation" model of relations with Israel. The failure to open an embassy in Israel at this stage was explained not by a lack of political will, but by a balancing strategy aimed at managing regional risks.

The study devotes special attention to the analysis of the position of the Islamic Republic of Iran in relation to Azerbaijani–Israeli relations. The contradictions between Iran's official rhetoric and practical behavior during both the First and Second Karabakh conflicts were assessed in the context of cooperation with Armenia, regional transit interests, and security concerns. In particular, the transfer of the 132 km section of the Iranian-Azerbaijani border to Baku's full control after the liberation of Karabakh in 2020 was interpreted as a decrease in Tehran's regional influence. The main analytical part of the dissertation is devoted to the deepening of Azerbaijani–Israeli relations on military-political, security, and economic grounds during the Ilham Aliyev era. During this period, military-technical cooperation, energy trade, and economic İnterdependence gave the relationship a strategic character. Azerbaijan's provision of a significant part of Israel's energy needs played an important role in the transition of bilateral relations to a political level. Finally, the dissertation analyzed Azerbaijan's decision to open a diplomatic mission in Israel against the background of new geopolitical realities that emerged after the SKW. This step was assessed not as a sudden and situational decision, but as a logical consequence of long-term strategic planning, a changing risk-benefit balance, and the strengthening of Azerbaijan's regional position. Thus, the opening of the embassy marked the transition of Azerbaijani–Israeli relations from a de facto stage of cooperation to de jure stage of institutionalization.

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The Problem of Updating Meaning: Semantic Shifts and Technological Vocabulary in Azerbaijani Online Dictionaries

Khatira Mammadova

Abstract: *This study aims to evaluate the extent to which the advantage of frequent updates provided by online dictionaries is utilized in monolingual Azerbaijani dictionaries. The words "axın", "bulud", "çərəz", and "tətbiq", all belonging to the technology semantic field, were selected as samples and examined in the "Azərbaycan dilinin izahlı lüğəti (2006). Dörd cilddə. Bakı: Şərq-Qərb." dictionary. The explanatory dictionary of the Azerbaijani language (2006, four volumes, Baku: Şərq-Qərb) remains the most recent comprehensive printed edition, and no subsequent updated edition has been published. Therefore, the observed limitations in reflecting recent semantic changes are not only related to lexicographic methodology, but also to the absence of an updated or revised edition after 2006. The English equivalents of the sample entries in the Cambridge and Oxford online monolingual English dictionaries were evaluated comparatively with the definitions in the Azerbaijani examples. This article investigates the problem of reflecting semantic shifts in online monolingual dictionaries. The author emphasizes that the language has a dynamic character and the meanings of the words change over time and gain new meanings. However, adherents of spiritual lexiconism have difficulty in reflecting these changes in an operational and academic way. The study shows that, although the numerical environment creates ample opportunities for the renewal of dictionaries, the selection, standardization and introduction of new meanings is still problematic. This creates particular complexity in the teaching process, because dictionaries are one of the main sources of reference for language learners and it is important for them to avoid using the actual language. The article concludes that online dictionaries should move towards more agile, user-oriented and corpus-based approaches. This will allow semantic changes to be traced more precisely and contemporary understandings to be properly presented in dictionaries.*

Keywords: *semantic shift, lexicography, online dictionaries, technological vocabulary, monolingual dictionaries, language change*

Nakhchivan State University, Nakhchivan, Azerbaijan
E-mail: hxatirem@gmail.com
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Mənanın yenilənməsi problemi: Azərbaycan onlayn lüğətlərində semantik dəyişikliklər və texnoloji terminologiya

Xatirə Məmmədova

Xülasə. *Bu tədqiqatın məAzərbaycan dilinin izndə (2006, dörd cilddə, Bakı: Şərq-Qərb) araşdırılmışdır. Bu lüğət Azərbaycan dilinin ən son genişhəcmli çap nəşri olaraq qalır və ondan sonra yenilənmiş nəşr dərc edilməmişdir.*

Buna görə də son dövrlərdə baş vermiş semantik dəyişikliklərin əks olunmasındakı çatışmazlıqlar yalnız leksikoqrafik metodologiya ilə deyil, həm də 2006-cı ildən sonra yenilənmiş və ya təkmilləşdirilmiş nəşrin olmaması ilə bağlıdır. Nümunə sözlərin ingilis dilindəki qarşılıqları Cambridge və Oxford onlayn birdilli ingilis dili lüğətlərində araşdırılmış və Azərbaycan dilindəki izahlarla müqayisəli şəkildə qiymətləndirilmişdir. Məqalədə onlayn birdilli lüğətlərdə semantik dəyişikliklərin əks etdirilməsi problemi tədqiq olunur. Müəllif vurğulayır ki, dil dinamik xarakter daşıyır, sözlərin mənaları zamanla dəyişir və yeni məna çalarları qazanır. Lakin ənənəvi leksikoqrafik yanaşmalar bu dəyişiklikləri operativ və elmi şəkildə əks etdirməkdə çətinlik çəkir. Araşdırma göstərir ki, rəqəmsal mühit lüğətlərin yenilənməsi üçün geniş imkanlar yaratsa da, yeni mənaların seçilməsi, standartlaşdırılması və lüğətlərə daxil edilməsi prosesi hələ də problemli olaraq qalır. Bu vəziyyət xüsusilə tədris prosesində çətinlik yaradır, çünki lüğətlər dil öyrənənlər üçün əsas istinad mənbələrindən biridir və onların müasir dil istifadəsindən geri qalmaması vacibdir. Məqalə belə nəticəyə gəlir ki, onlayn lüğətlər daha çevik, istifadəçi yönümlü və korpus əsaslı yanaşmalara üstünlük verməlidir. Bu, semantik dəyişikliklərin daha dəqiq izlənilməsinə və müasir mənaların lüğətlərdə düzgün təqdim olunmasına imkan verəcəkdir.

Açar sözlər: *semantik dəyişiklik, leksikoqrafiya, onlayn lüğətlər, texnoloji terminologiya, birdilli lüğətlər, dil dəyişikliyi*

Naxçıvan Dövlət Universiteti, Naxçıvan, Azərbaycan
E-poçt: hxatirem@gmail.com
Daxil oldu: 3 Fevral 2026; Qəbul edildi: 5 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

Language as a social phenomenon is not only a means of communication, but also a dynamic system that sensitively reacts to social, cultural and technological transformations occurring within society. In this regard, the characterization of language as a "living" structure reflects its constantly changing and developing nature. These dynamics manifest themselves both at the lexical level (in vocabulary) and at the structural level. As a result of new realities and concepts emerging in society, either new words are formed, or existing words are expanded semantically and acquire new shades of meaning. In this process, dictionaries act not only as sources describing language units, but also as important lexicographic tools that document semantic changes and, in a certain sense, provide normative direction. Influenced by this living nature of language, dictionaries have undergone various changes over time, both in terms of their general structure (megastructure) and the organization of dictionary entries (Mammadova, 2025). The most important of these transformations is the transition from printed dictionaries to online dictionaries. While the updating process in traditional printed dictionaries takes place over long periods, online dictionaries offer more flexible and operational opportunities.

According to Elizabeth Closs Traugott, semantic change is a systematic and inherent process in natural languages that reflects shifts in usage and conceptualization. This process has accelerated dramatically in the digital era, particularly in the field of technological vocabulary. Robert Lew emphasizes that online monolingual dictionaries, due to their flexibility and updateability, are better positioned to respond to such developments compared to printed dictionaries, where long revision cycles hinder timely updates. The increasing role of digital technologies has also strengthened the user-oriented approach in modern lexicography. Online dictionaries enable faster inclusion of newly emerging words and meanings, thereby reflecting contemporary language use more effectively.

However, the extent to which this potential is realized varies across languages and lexicographic traditions.

The main purpose of this study is to determine to what extent the operational updating potential of online dictionaries is effectively applied in Azerbaijani monolingual explanatory dictionaries. For this purpose, lexical units such as “axın” (stream), “bulud” (cloud), “çərəz” (cookie), and “tətbiq” (application), which have undergone significant semantic change in the field of information technologies, were selected and analyzed comparatively. The analysis allows for evaluating the degree to which modern concepts are reflected in dictionaries, as well as their relevance and suitability for contemporary language use.

Although online explanatory dictionaries have the potential to respond more effectively to the dynamic development of language, this potential can only be fully realized through systematic updating strategies, expanded corpus-based approaches, and more precise monitoring of semantic change. These issues highlight the need for a deeper examination of current lexicographic practices, which is addressed in the following section.

The issue of semantic change and its representation in dictionaries has been widely discussed in modern linguistic and lexicographic research. Scholars emphasize that semantic change is not random, but a systematic and usage-based process shaped by cognitive, social, and technological factors. According to Traugott and Dasher, semantic shifts occur through mechanisms such as metaphorical extension, functional reanalysis, and pragmatic strengthening, leading to the gradual emergence of new meanings in language. In lexicography, one of the central challenges is how effectively these evolving meanings are reflected in dictionary entries. Lew (2013) notes that the transition from printed to online dictionaries has significantly transformed lexicographic practices by introducing flexibility, rapid updating, and user-oriented design. Unlike printed dictionaries, online platforms can incorporate new lexical items and semantic changes in a shorter time frame.

Recent research highlights the importance of corpus-based approaches in dictionary compilation. Corpus linguistics enables the analysis of large-scale language data, allowing lexicographers to identify frequency patterns, emerging meanings, and contextual usage more accurately. Nedashkivska (2025) argues that the integration of dynamic corpora enhances the relevance and reliability of dictionary entries, particularly in rapidly evolving domains such as technological vocabulary. Another important development is the increasing role of user participation in lexicography. Interactive platforms and feedback mechanisms allow users to identify outdated definitions and propose new meanings, contributing to a more dynamic and descriptive model of dictionary development. This reflects a shift from traditional prescriptive approaches toward user-driven lexicographic practices.

Furthermore, artificial intelligence technologies have introduced new possibilities for monitoring semantic change. Machine learning tools can analyze large textual datasets, detect emerging lexical patterns, and support lexicographers in prioritizing updates. These technologies are especially valuable in tracking rapidly changing semantic fields. Despite these advancements, not all languages benefit equally from modern lexicographic innovations. English dictionaries, such as Cambridge and Oxford, demonstrate a high level of responsiveness to semantic change, whereas less-resourced languages often experience delays in updating dictionary content. This creates a gap between actual language use and its lexicographic representation. In the context of Azerbaijani lexicography, research on the reflection of semantic change particularly in the field of technological vocabulary remains limited. Existing studies mainly focus on general lexicographic principles or terminological dictionaries, while the issue of updating monolingual explanatory dictionaries in response to semantic expansion has not been sufficiently explored.

Therefore, this study aims to address this gap by comparatively analyzing selected lexical items and evaluating the extent to which contemporary semantic changes are reflected in Azerbaijani online dictionaries in comparison with English lexicographic practice. The novelty of this study lies in its focused examination of how semantic change in technological vocabulary is reflected in Azerbaijani monolingual explanatory dictionaries in comparison with English online dictionaries. While previous research has mainly addressed general lexicographic principles or terminological dictionary compilation, limited attention has been given to the systematic analysis of semantic shifts in explanatory dictionaries of Azerbaijani, particularly in the field of rapidly evolving technological vocabulary.

Unlike earlier studies, this research adopts a comparative lexicographic approach based on real dictionary data and selected high-frequency lexical items ("stream", "cloud", "cookie", "application") that demonstrate clear cases of semantic expansion. This allows for identifying not only the presence or absence of new meanings but also the degree of responsiveness of dictionaries to contemporary language change.

Another innovative aspect of the study is its emphasis on the gap between technological language use and its lexicographic representation. By comparing Azerbaijani and English dictionary practices, the study highlights structural and methodological differences in how semantic change is recorded and updated. The contribution of this research is twofold. First, it provides empirical evidence of the current limitations in Azerbaijani lexicographic practice regarding the integration of new technological meanings. Second, it offers a conceptual basis for improving dictionary updating mechanisms by emphasizing the need for corpus-based monitoring, systematic revision of existing entries, and more responsive online lexicographic systems. In this sense, the study contributes both to theoretical lexicography, by deepening the understanding of semantic change representation, and to applied lexicography, by suggesting practical directions for improving dictionary development in the digital era.

Purpose and Research Questions

This research aims to analyze the degree to which Azerbaijani dictionaries available online represent technological semantic change and also evaluate how effectively they demonstrate currently existing language. This research focuses on a minimum number of selected lexical terms and compares their treatments within Azerbaijani explanatory dictionaries with those of their modern English counterparts. The research addresses the following questions:

1. How much do recently developed technical meanings appear in Azerbaijani online explanatory dictionaries?
2. How do these depictions differ from those seen in modern online dictionaries for English?
3. What obstacles must be overcome in order to apply semantic shifts in Azerbaijani lexicographic practice?

Methods

This study employs a qualitative, descriptive, and comparative research design within the framework of lexicographic analysis. The qualitative approach is appropriate for this research because it focuses on the interpretation of dictionary definitions and semantic change rather than numerical measurement or statistical generalization (Creswell, 2014). The comparative method is used to examine differences between Azerbaijani and English dictionaries in representing technological semantic shifts.

The analysis of selected technological lexical units (stream, cloud, cookie, application) was carried out in the following steps:

In the first stage, the lexical units that served as the object of research were identified. During this selection, the main criterion was that the words had both a traditional meaning and had acquired new semantic meanings in the field of information technologies in the modern era. This purposive sampling technique is commonly used in qualitative linguistic studies to select information-rich cases relevant to the research problem (Patton, 2002). In the second stage, the explanations of the selected words in Azerbaijani were collected. For this purpose, both printed and online versions of the *"Explanatory Dictionary of the Azerbaijani Language"* were consulted, and the meanings, definitions, and possible semantic extensions of each word were recorded. In the third stage, the English equivalents of these lexical units (stream, cloud, cookie, application/app) were identified, and their definitions were collected from authoritative online dictionaries such as the Cambridge Dictionary and Oxford Learner's Dictionaries. These sources are widely recognized in lexicographic research for their corpus-based and usage-oriented approach (Lew, 2013).

In the fourth stage, the dictionary materials obtained in Azerbaijani and English were analyzed comparatively. During this analysis, the following criteria were taken into account: whether technological meanings were included, how semantic changes (such as expansion or metaphorical extension) were represented, the accuracy of definitions, and the marking of usage domains. Comparative lexicographic analysis is a standard method in contrastive linguistics for identifying similarities and differences in meaning representation across languages (Swanepoel, 2001). In the fifth stage, the results of the comparison were summarized, and the extent to which Azerbaijani online dictionaries reflect modern semantic changes was assessed. In particular, the representation of rapid developments in technological vocabulary was analyzed. In the final stage, based on the findings, existing problems related to dictionary updating, semantic change tracking, and lexicographic methodology were identified, and suggestions for improvement were formulated.

Data Collection Tool and Data Analysis

The data were collected through document analysis of online monolingual dictionaries. Selected lexical items were identified and their definitions were systematically examined. Data analysis was conducted using a qualitative comparative approach, focusing on the presence, accuracy, and currency of semantic representations. The findings were evaluated in terms of how effectively semantic shifts are reflected in the dictionaries.

Theoretical Framework

The issue of dictionary updating is one of the central concerns of modern lexicography. Updating is not limited to the inclusion of new lexical items, but also involves the systematic revision of existing dictionary entries in terms of structure, content, and semantic accuracy. In this process, the definition component plays a crucial role, as it directly determines the relevance, reliability, and usability of dictionary entries. However, in public perception, dictionary updating is often associated primarily with the addition of new words, while the revision of existing meanings and definitions tends to receive less attention. This creates a discrepancy between actual language use and its lexicographic representation. Therefore, in applied lexicography, updating requires not only expansion but also continuous content evaluation and systematic editorial revision. The representation of terms in dictionaries constitutes another important aspect of this process. Dictionaries do not merely provide meanings; they also reflect usage, context, grammatical features, and semantic relations, thereby offering a comprehensive description of language (Abdelzaher, 2022). In particular, the inclusion of technological and specialized vocabulary enhances the relevance of dictionaries and supports both professional communication and language learning.

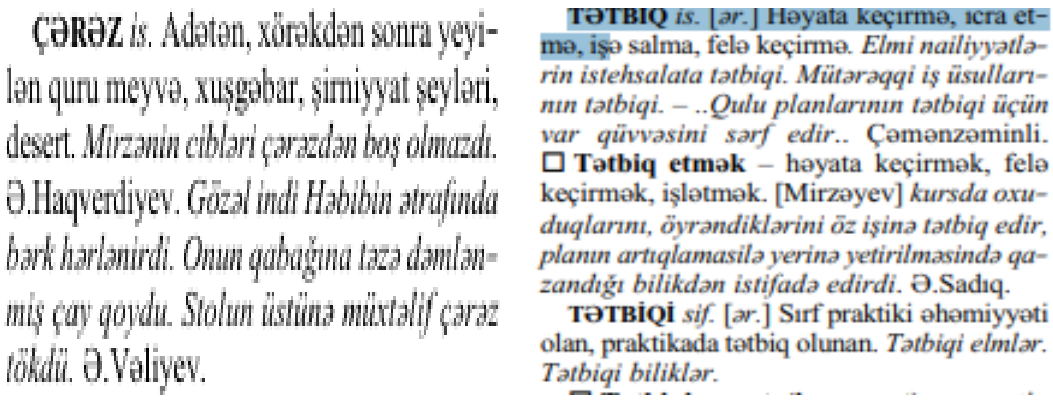
Terminological dictionaries encode the conceptual systems of specific fields, whereas explanatory dictionaries aim to serve a broader audience by reflecting general language use. In this regard, the inclusion of widely used technological meanings in explanatory dictionaries is essential, as these meanings increasingly become part of everyday communication. At the same time, the selection of such terms should be guided by criteria such as frequency of use, semantic relevance, and accessibility to general users. Another key principle in modern lexicography is the recognition that dictionary definitions are not static but dynamic structures that evolve over time. This transformation is influenced not only by internal linguistic changes but also by developments in knowledge, culture, and technology. As a result, both the lexical-semantic system of language and the metalanguage used in dictionary definitions may become outdated or require revision (Ismayilli, 2025). The obsolescence of dictionary entries may arise from various factors, including the expansion or narrowing of semantic fields, changes in social and stylistic usage, and shifts in real-world knowledge (Mammadli, 2023). For instance, lexical items previously considered informal or marginal may gradually become part of standard language (Tahmasebi, 2018). In addition, external factors such as technological advancement and socio-cultural change significantly influence the relevance of definitions.

Technological development, in particular, plays a crucial role in semantic renewal. Many concepts that were once defined primarily through their physical properties are now reinterpreted in functional or digital terms. Moreover, activities that previously occurred only in physical environments are increasingly carried out in virtual spaces, which necessitates the expansion and reformulation of existing lexical meanings (Alguliyev, 2024). In addition to technological factors, social values and ethical norms also contribute to semantic change. The replacement of certain expressions with more inclusive and socially sensitive alternatives reflects broader societal transformations as well as linguistic evolution. Within this theoretical context, the present study aims to determine the extent to which online monolingual dictionaries in the Azerbaijani language effectively utilize their potential for continuous updating. The focus is placed on the reflection of semantic changes in the field of technology, where lexical innovation and meaning expansion occur most intensively.

For this purpose, lexical units such as “streaming”, “cloud”, “cookie”, and “application”, which have undergone significant semantic expansion in contemporary usage, were selected as the objects of analysis (Babasoy et al., 2025, p. 5). These items represent cases where traditional meanings coexist with newly developed technological meanings. A comparative approach was adopted, in which the representation of these lexical items in Azerbaijani explanatory dictionaries was examined and compared with their equivalents in modern English online dictionaries. This approach allows for evaluating the extent to which contemporary semantic developments are reflected in Azerbaijani lexicographic practice.

Preliminary observations indicate that the technological meanings of certain lexical items are either insufficiently represented or entirely absent in Azerbaijani explanatory dictionaries. For example, the word “cloud”, in its technological sense referring to an internet-based data storage system, is not reflected in the dictionary, despite its widespread usage. A similar situation is observed with the word “cookie”, whose meaning related to data storage in web technologies is not adequately represented. These findings point to a gap between actual language use and its lexicographic representation, emphasizing the need for more systematic, dynamic, and responsive updating strategies in Azerbaijani online dictionaries.

The word “application” is also one of the clearest examples of semantic expansion. Especially with the development of mobile and digital technologies, this word has become widespread in the sense of “software”. However, it is observed that this new semantic layer is either incomplete or not presented at all in explanatory dictionaries. This shows that dictionaries do not fully reflect modern language usage.



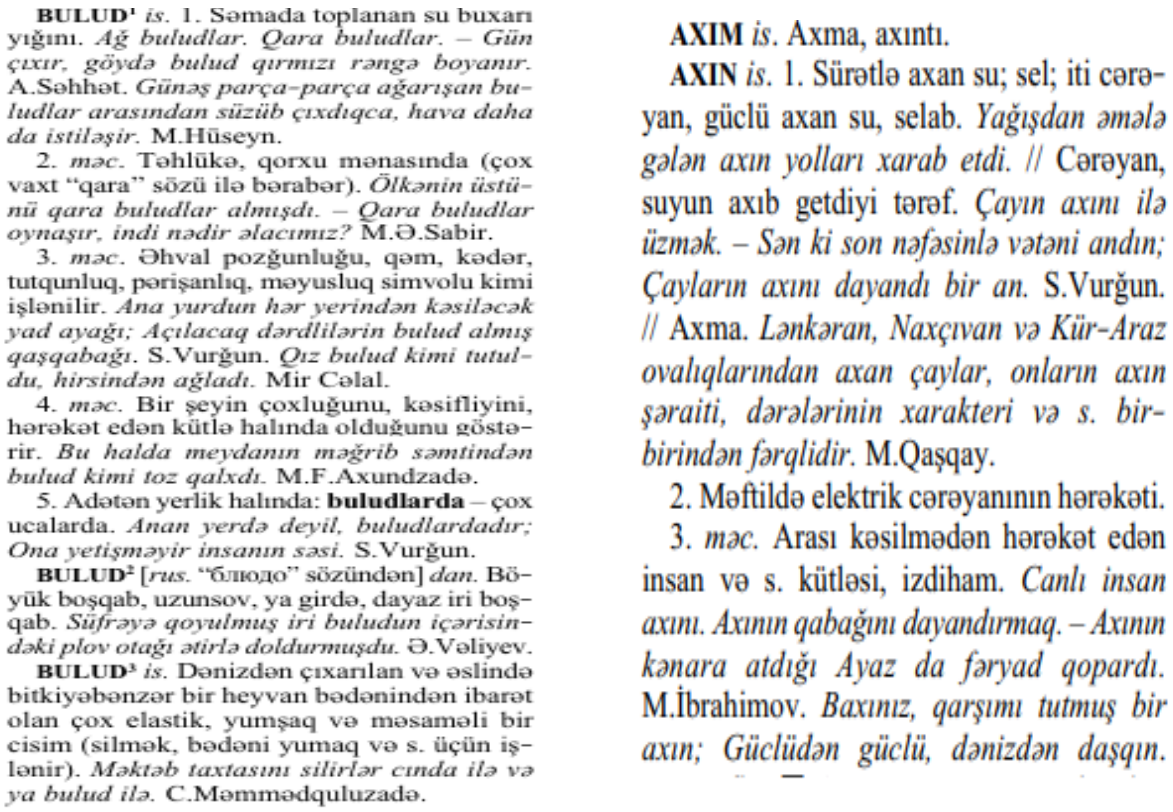
ÇƏRƏZ *is.* Adətən, xörəkdən sonra yeyilən quru meyvə, xuşgəbar, şirniyyat şeyləri, desert. *Mirzənin cibləri çərəzdən boş olmazdı.* Ə.Haqverdiyev. *Gözəl indi Həbibin ətrafında bərk hərlənirdi. Onun qabağına təzə dəmlənmiş çay qoydu. Stolun üstünə müxtəlif çərəz tökdü.* Ə.Vəliyev.

TƏTBİQ *is.* [*ər.*] Həyata keçirmə, icra etmə, işə salma, felə keçirmə. *Elmi nailiyyətlərin istehsalata tətbiqi. Mütərəqqi iş üsullarının tətbiqi. – ..Qulu planlarının tətbiqi üçün var qüvvəsini sərf edir..* Çəmənzəminli. ☐ **Tətbiq etmək** – həyata keçirmək, felə keçirmək, işlətmək. [Mirzəyev] *kursda oxuduqlarını, öyrəndiklərini öz işinə tətbiq edir, planın artıqlamasilə yerinə yetirilməsində qazandığı bilikdən istifadə edirdi.* Ə.Sadıq.

TƏTBİQİ *sif.* [*ər.*] Sırf praktiki əhəmiyyəti olan, praktikada tətbiq olunan. *Tətbiqi elmlər. Tətbiqi biliklər.*

Figure 1

Words taken from Azerbaijani dictionary.
(https://urmu.eu/Azerbaycan_dilinin_izahli_lugeti_3.pdf)



BULUD[1] *is.* 1. Səmada toplanan su buxarı yığını. *Ağ buludlar. Qara buludlar. – Gün çıxır, göydə bulud qırmızı rəngə boyanır.* A.Səhhət. *Günəş parça-parça ağarışan buludlar arasından süzüb çıxdıqca, hava daha da istiləşir.* M.Hüseyn.

2. *məc.* Təhlükə, qorxu mənasında (çox vaxt "qara" sözü ilə bərabər). *Ölkənin üstünü qara buludlar almışdı. – Qara buludlar oynaşır, indi nədir əlacımız?* M.Ə.Sabir.

3. *məc.* Əhval pozğunluğu, qəm, kədər, tutqunluq, pərişanlıq, məyusluq simvolu kimi işlənilir. *Ana yurdun hər yerindən kəsiləcək yad ayağı; Açılacaq dərdlilərin bulud almış qaşqabağı.* S.Vurğun. *Qız bulud kimi tutuldu, hirsindən ağladı.* Mir Cəlal.

4. *məc.* Bir şeyin çoxluğunu, kəsifliyini, hərəkət edən kütlə halında olduğunu göstərir. *Bu halda meydanın mağrib səmtindən bulud kimi toz qalxdı.* M.F.Axundzadə.

5. Adətən yerlik halında: **buludlarda** – çox ucalarda. *Anan yerdə deyil, buludlardadır; Ona yetişməyir insanın səsi.* S.Vurğun.

BULUD[2] [*rus.* "блюдо" sözündən] *dan.* Böyük boşqab, uzunsov, ya girdə, dayaz iri boşqab. *Süfrəyə qoyulmuş iri buludun içərisindəki plov otağı ətirlə doldurmuşdu.* Ə.Vəliyev.

BULUD[3] *is.* Dənizdən çıxarılan və əslində bitkiyəbənzər bir heyvan bədənindən ibarət olan çox elastik, yumşaq və məsaməli bir cisim (silmək, bədəni yumaq və s. üçün işlənir). *Məktəb taxtasını silirlər cındа ilə və ya bulud ilə.* C.Məmmədquluzadə.

AXIM *is.* Axma, axıntı.

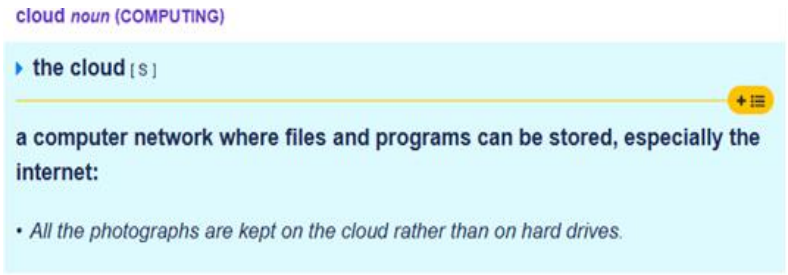
AXIN *is.* 1. Sürətlə axan su; sel; iti cərəyan, güclü axan su, selab. *Yağışdan əmələ gələn axın yolları xarab etdi.* // Cərəyan, suyun axıb getdiyi tərəf. *Çayın axını ilə üzmək. – Sən ki son nəfəsinlə vətəni andın; Çayların axını dayandı bir an.* S.Vurğun. // Axma. *Lənkəran, Naxçıvan və Kür-Araz ovalıqlarından axan çaylar, onların axın şəraiti, dərələrinin xarakteri və s. birbirindən fərqlidir.* M.Qaşqay.

2. Məftildə elektrik cərəyanının hərəkəti.

3. *məc.* Arası kəsilmədən hərəkət edən insan və s. kütləsi, izdiham. *Canlı insan axını. Axının qabağını dayandırmaq. – Axının kənara atdığı Ayaz da fəryad qopardı.* M.İbrahimov. *Baxınız, qarşımı tutmuş bir axın; Güclüdən güclü, dənizdən daşqın.*

Figure 2

Words taken from Oxford and Cambridge online dictionaries

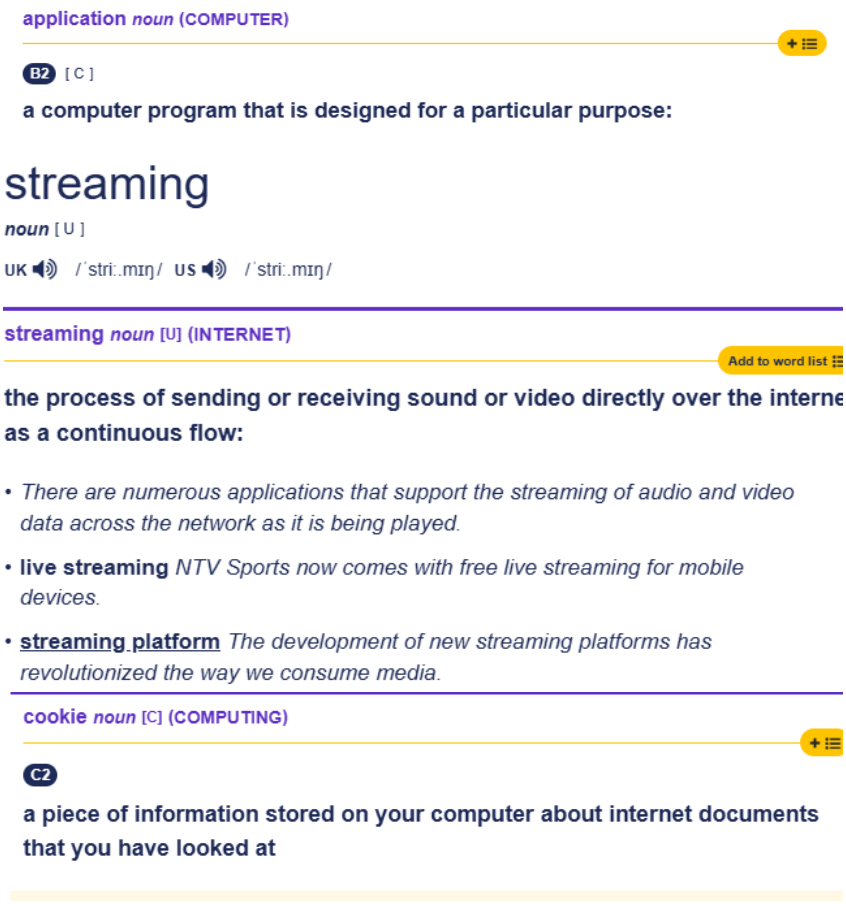


cloud *noun* (COMPUTING)

▸ **the cloud** [S]

a computer network where files and programs can be stored, especially the internet:

• *All the photographs are kept on the cloud rather than on hard drives.*



application *noun* (COMPUTER)

B2 [C]

a computer program that is designed for a particular purpose:

streaming

noun [U]

UK /ˈstriːmɪŋ/ US /ˈstriːmɪŋ/

streaming *noun* [U] (INTERNET)

Add to word list

the process of sending or receiving sound or video directly over the interne as a continuous flow:

- *There are numerous applications that support the streaming of audio and video data across the network as it is being played.*
- **live streaming** *NTV Sports now comes with free live streaming for mobile devices.*
- **streaming platform** *The development of new streaming platforms has revolutionized the way we consume media.*

cookie *noun* [C] (COMPUTING)

C2

a piece of information stored on your computer about internet documents that you have looked at

However, the meaning of all the terms we mentioned is explained in Ismayil Jellali's 997-page "Explanatory Dictionary of Informatics Terms" Baku Publishing House-2017 dictionary Figure 3. (terms taken from terminology dictionary). www.oxfordlearnersdictionaries.com

cookie <kuki> – "**qurabiyə**". HTTP protokolu tərəfindən dəstəklənən, ölçüsü 4 Kbaytadək olan və istifadəçi haqqında verilənlərdən ibarət olan mətn yazısı; istifadəçinin qeydiyyatı zamanı veb-server tərəfindən qaytarılır və istifadəçinin kompüterində saxlanır. İlk dəfə Netscape Communications şirkəti tərəfindən daxil edilib. *Kuki*-fayllara saytı ziyarət tarixçəsi, gözdən keçirilən səhifələr, sayta daxil olarkən aparılmış fərdi kökləmələr, baxılan reklamların siyahısı, hər bir istifadəçinin üstünlük verdikləri yazıla bilər və bu informasiyanın əsasında hər dəfə müştəri sayta girərkən ona konkret təkliflər verilə bilər. (Ziyarətlərin tarixçəsi saytda verilənlər bazasında aparıla bilər, *kuki*-faylda isə yalnız bu verilənlər bazasındakı yazıların indeksləri yerləşdirilir.) Ancaq şəbəkə istifadəçilərinin istəmədiyi halda belə informasiya toplanışı onların haqlı iradına səbəb olur. *Kuki*-faylların uzaqlaşdırılması istifadəçinin kompüterinin işinə təhlükə yaratmır.

cloud computing ~ **облачные вычисления** ~ **bulut bilişim** ~ **bulud hesablamalar** – hesablama resurslarını yerləşdirmək və belə xidmətləri son uc istifadəçilərə təqdim etmək üçün İnternetdən istifadəyə imkan verən texnologiya. *Bulud hesablamalardan* istifadə olunması tətbiqi proqramlara xidmət göstəriləməsini və verilənlərin saxlanmasını çox yüksək etibarlılığa malik sistemlərə həvalə etməyə, praktik olaraq qeyri-məhdud resurslar təqdim etməyə, xidmət haqqını dəfələrlə azaltmağa və istifadəçilərə hazır servis təqdim etməyə imkan verir.
İri şirkətlər çox vacib informasiyalarını saxlamaq üçün kənar provayderlərə etibar etmədiyindən özəl "buludlarını" yaratmağa üstünlük verir.

application ~ **приложение** ~ **uygulama** ~ **tətbiqi proqram** – birtipli (oxşar) işləri yerinə yetirmək üçün nəzərdə tutulmuş xüsusi proqram. *Tətbiqi proqramlara* örnək olaraq mətn prosessorlarını, elektron cədvəlləri, mühasibat sistemlərini göstərmək olar. *Tətbiqi proqramı* kompüteri idarə edən əməliyyat sistemindən, yardımçı (xidməti) məsələləri və ya ümumi təyinatlı funksiyaları yerinə yetirən utilitdən və proqramların yazıldığı proqramlaşdırma dilindən fərqləndirmək lazımdır. *Tut*: OPERATING SYSTEM, PROGRAMMING LANGUAGE, UTILITY.

Table 1
Comparison between the dictionaries

Lexical Item (AZ)	Traditional Meaning (AZ Dictionary)	Technological Meaning (AZ Dictionary)	English Equivalent	Technological Meaning (EN Dictionaries)	Semantic Shift Type	Notes
Axın	Mayenin fasiləsiz hərəkəti	yoxdur / qeyd olunmayıb	stream	data stream (continuous flow of data)	Metaphorical extension	AZ lüğətdə texnoloji məna yoxdur
Bulud	Göydə su buxarı kütləsi	yoxdur	cloud	internet-based storage system	Functional shift	İngilis dili lüğətində əsas mənalardan biridir
Çərəz	Şirniyyat növü	yoxdur	cookie	small data stored by websites	Metaphorical shift	Azərbaycan dili lüğətində yalnız məişət mənasında verilib
Tətbiq	müraciət, tətbiq etmə	qismən natamam	application (app)	software program	Semantic expansion	Azərbaycan dili lüğətində bütün mənalar verilməyib

In conclusion, the study shows that although online dictionaries have the ability to be updated quickly from a technical point of view, this potential is not always fully realized in practice. Especially in rapidly developing areas such as technology, the prompt, systematic and adequate inclusion of semantic innovations in dictionaries remains one of the priority directions of modern lexicography. This necessitates the development of new methodological approaches at both the theoretical and applied levels.

Position of Technological Terms in Explanatory Dictionaries

One of the main problems in modern Azerbaijani lexicography is determining the extent and form of technological terms in explanatory (monolingual) dictionaries. Terminological dictionaries are prepared for a specific audience and provide precise technical definitions, but the purpose of explanatory dictionaries is to cover a wider audience and reflect the actual use of the language. This difference plays an important role in the presentation of semantic changes, especially the rapid innovations in the field of technology, in dictionaries.

For example, the words cloud, cookie, application, and stream were originally used in a technical context, but in recent years these words have become widespread in everyday language and have acquired new meanings. In such cases, the inclusion of these meanings in explanatory dictionaries is not only recommended, but also necessary, since one of the main functions of the dictionary is to show users the modern use of the language (Arias, 2024). Failure to include these meanings can create a gap between the dictionary and real language use, creating misunderstandings and difficulties, especially for language learners. However, it is not appropriate to automatically add all technological or newly created terms to explanatory dictionaries (Adilov et al., 2019). Rarely used, highly specialized words should remain in glossaries, because they are important to specialists and at the same time allow the glossary to be maintained without increasing its size. Therefore, the criteria for inclusion in the dictionary should be determined on the basis of frequency of use, semantic relevance and level of understanding of general users, and not simply on the basis of technical availability.

As a result, dictionaries should adopt a balanced approach when including technological meanings. Technological words that are already widespread in everyday speech should be included, but very specific and rare terms should be kept only in terminological dictionaries. This approach will allow

dictionaries to remain relevant, reliable and user-oriented, as well as to more fully and accurately reflect the modern lexicon of the Azerbaijani language.

Discussion and Recommendations

The studies conducted show that Azerbaijani explanatory dictionaries are slow to add words and/or newly acquired meanings in the field of technology, or have not made any progress at all. The fact that none of the words and meanings that make up the sample are included in the explanatory dictionary is a clear example of this situation. The comparison shows that modern English dictionaries, especially the Cambridge Dictionary and the Oxford Learner's Dictionaries, systematically and promptly reflect the semantic changes taking place in the technological field (UNESCO, 2023). In these dictionaries, not only the traditional meanings of words, but also the new functional and terminological meanings they have acquired in the modern digital context are separately noted and often presented as one of the main meanings.

In contrast, in explanatory dictionaries of the Azerbaijani language, the technological meanings of the same lexical units are either not presented at all or are given incompletely. This creates a discrepancy between the dictionary and real language use. It is particularly noteworthy that in English, words such as "cloud", "cookie", "stream" and "application" have already become established as technological terms in everyday use and are systematically presented in dictionaries as such. However, the same semantic expansion of their Azerbaijani counterparts "bulud", "çərəz", "axın" and "tətbiq" has not been adequately reflected in dictionaries.

This difference shows that while English lexicography adopts a more flexible and user-oriented approach to tracking semantic changes, this process in Azerbaijani lexicography is slower and less systematic. It is certainly not correct to include every concept that emerges in an age where technology and cultural changes are happening so rapidly in the dictionary. Or, the inclusion of concepts that have not yet reached sufficient usage and should remain as terms can unnecessarily increase the size of the dictionary.

However, an important decision needs to be made at this point. Because the exclusion of newly emerging and highly frequent concepts from the dictionary, thus preventing them from gaining legitimacy, may lead to their English equivalents becoming established in the language. From this perspective, determining whether existing dictionary entries maintain their conceptual validity over time requires a process in itself. As a solution:

User-oriented feedback mechanisms A crowdsourcing system should be implemented for professional lexicographers and active users, where users can mark outdated explanations and suggest new technological meanings. A voting or approval mechanism should be created that ensures that suggestions are prioritized according to importance and frequency of use.

Corpus-based monitoring In addition to written texts, a continuously updated language corpus should be developed that includes online forums, social media, and technical publications. This corpus can be used to monitor new terms and semantic changes, and determine which terms are relevant for inclusion in the dictionary.

Tagging and classification for dynamic review New technological terms or user-suggested meanings should be tagged as "current use" or "candidate for inclusion". Vocabulary items should be grouped by semantic domain, with periodic review focusing on rapidly changing domains.

Integration of artificial intelligence technologies AI tools that automatically detect new terms and semantic changes in large corpora should be implemented. Machine learning algorithms should help lexicographers prioritize updates by highlighting gaps in existing explanations.

Balanced inclusion policy Frequently used technological terms should be included promptly, while highly specialized and rare terms should be kept in glossaries. Inclusion criteria should be based on frequency, semantic relevance, and level of understanding by a broad user group.

In this context, creating a continuously updated database and incorporating it into the dictionary compilation process will be a crucial tool for ensuring the sustainability of dictionaries. The active use of artificial intelligence technologies, which are becoming increasingly accessible to a wider audience, will be a turning point in addressing the issue of currency in dictionaries, as it is in all lexicographical studies.

Conclusion

The findings of this study indicate that Azerbaijani explanatory dictionaries do not fully reflect the semantic innovations of technological vocabulary. The analysis of lexical items such as "axın", "bulud", "çərəz", and "tətbiq" shows that their contemporary technological meanings are either incomplete or entirely absent. This creates a gap between dictionary content and actual language use, weakening the functional and normative role of dictionaries. This issue is particularly significant for language learners, as dictionaries serve as primary reference tools. The lack of up-to-date meanings limits learners' ability to understand and use words accurately in modern communicative contexts, negatively affecting their language competence. At the same time, not all technological terms should be included in explanatory dictionaries. A balanced approach is required, considering factors such as frequency, semantic relevance, and user needs, while highly specialized terms should remain within terminological dictionaries. The study highlights the need for more dynamic and systematic updating practices in Azerbaijani lexicography. In this regard, the adoption of corpus-based methods, user-oriented approaches, and digital technologies can significantly improve the accuracy, relevance, and usability of dictionaries. In conclusion, the continuous and systematic updating of explanatory dictionaries is essential for reflecting contemporary language use and supporting effective language learning.

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Media diskursunda ideologiya və metaforik çərçivələmə: CDA və koqnitiv dilçilik təhlili

Mətanət Hacıyeva[1], Elnarə Məmmədova[2*], Zülfiyyə Ağayeva[3]

Xülasə. *Bu tədqiqat müasir siyasi media diskursunda ideoloji konstruksiyaların formalaşmasını Kritik Diskurs Analizi (CDA), Koqnitiv Dilçilik və Konseptual Metafora Nəzəriyyəsinin inteqrativ çərçivəsi əsasında araşdırır. Tədqiqatın empirik bazasını 2024–2026-cı illər arasında BBC, CNN, Reuters və rəsmi siyasi bəyanatlardan seçilmiş 150 media mətni (təxminən 120.000 söz) təşkil edir. Tədqiqat qarışıq metodoloji yanaşmaya (keyfiyyət və kəmiyyət analizlərinin inteqrasiyası) əsaslanır. Van Dijk-in sosiokoqnitiv CDA modeli və Lakoff & Johnson-un konseptual metafora nəzəriyyəsi əsasında aparılan analiz nəticəsində media diskursunda sistemli ideoloji qütbləşmə, "biz–onlar" qarşıdurması, metaforik çərçivələmə və praqmalingvistik manipulyasiya strategiyaları müəyyən edilmişdir. Kəmiyyət nəticələri müxtəlif media platformaları arasında leksik seçim, agentlik strukturları və emosional leksikanın paylanmasında statistik baxımdan əhəmiyyətli fərqlərin olduğunu göstərir. Nəticələr sübut edir ki, media diskursu yalnız informasiya ötürmə vasitəsi deyil, eyni zamanda ictimai şüuru formalaşdıran koqnitiv-ideoloji mexanizmdir. Araşdırma media mətnlərində çərçivələmə strategiyalarının davamlılığını və ideoloji reproduksiya mexanizmlərini vurğulayır. Bu yanaşma müasir kommunikasiya mühitində media təsirinin daha dərindən anlaşılmasına imkan yaradır və gələcək tədqiqatlar üçün müxtəlif regionları əhatə edən müqayisəli media diskursu analizi istiqamətləri təklif olunur kimi prioritet sahələr.*

Açar sözlər: *kritik diskurs analizi, koqnitiv dilçilik, media diskursu, konseptual metafora, ideologiya, çərçivələmə*

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[1]Azərbaycan Memarlıq və İnşaat Universiteti, Bakı, Azərbaycan
[2]Azərbaycan Tibb Universiteti, Bakı, Azərbaycan
[3]Azərbaycan Memarlıq və İnşaat Universiteti, doktorant, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: ememmedova69@mail.com
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Ideology and Metaphorical Framing in Media Discourse: A Critical Discourse Analysis and Cognitive Linguistics Study

Matanat Hajiyeva[1], Elnara Mammadova[2*], Zulfiya Aghayeva[3]

Abstract. *This study investigates the formation of ideological constructions in contemporary political media discourse through the integrated framework of Critical Discourse Analysis (CDA), Cognitive Linguistics, and Conceptual Metaphor Theory. The empirical corpus consists of 150 media texts (approximately 120,000 words) selected from BBC, CNN, Reuters, and official political statements published between 2024 and 2026.*

The study is based on a mixed-methods approach integrating both qualitative and quantitative analyses. Using Van Dijk's socio-cognitive model of CDA and Lakoff & Johnson's Conceptual Metaphor Theory, the analysis identifies systematic ideological polarization in media discourse, in-group/out-group ("us vs. them") opposition, metaphorical framing strategies, and pragmalinguistic manipulation strategies. Quantitative results indicate statistically significant differences across media platforms in lexical choices, agency structures, and the distribution of emotional vocabulary. The findings demonstrate that media discourse functions not only as a means of information transmission but also as a cognitive-ideological mechanism that shapes public consciousness. The study highlights the persistence of framing strategies in media texts and the mechanisms of ideological reproduction. This approach enables a deeper understanding of media influence in contemporary communication environments and proposes directions for future research, particularly comparative media discourse analysis covering different regions as a priority area.

Keywords: *critical discourse analysis, cognitive linguistics, media discourse, conceptual metaphor, ideology, framing*

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[1]Azerbaijan University of Architecture and Construction, Baku, Azerbaijan
[2]Azerbaijan Medical University, Baku, Azerbaijan
[3]Azerbaijan University of Architecture and Construction, PhD student, Baku, Azerbaijan
[*]Corresponding author. E-mail: ememmedova69@mail.com
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Giriş

Müasir qloballaşma, transmilli informasiya axınlarının intensivləşməsi və rəqəmsal transformasiya şəraitində kütləvi informasiya vasitələri (KİV) artıq yalnız informasiya ötürücüsü və ya neytral müşahidəçi kimi çıxış etmir. Əksinə, media korporasiyaları və rəqəmsal platformalar ictimai rəyin formalaşdırılması, siyasi və geosiyasi reallıqların interpretasiyası və kollektiv şüurun yönləndirilməsi prosesində mühüm diskursiv və ideoloji aktorlara çevrilmişdir. Bu kontekstdə media diskursunun siyasi və koqnitiv dilçilik çərçivəsində tədqiqi müasir linqvistik və interdisiplinar araşdırmaların mühüm istiqamətlərindən biri kimi çıxış edir. Xüsusilə media mətnlərində ideoloji strukturların, latent qərəzliliyin və manipulyativ diskurs strategiyalarının aşkarlanması Kritik Diskurs Analizinin (Critical Discourse Analysis – CDA) əsas tədqiqat sahələrindəndir (Avdagić, 2023, s. 63–98).

Siyasi media diskursu mahiyyət etibarilə neytral xarakter daşımır; o, güc münasibətlərini, ideoloji mövqeləri və geosiyasi maraqları əks etdirən praqmatik və funksional dil praktikası kimi fəaliyyət göstərir. Media institutları xəbər istehsalı və gündəm formalaşdırma prosesində seçilmiş leksik vahidlər, sintaktik strukturlar və konseptual metaforalar vasitəsilə hadisələri müəyyən ideoloji çərçivələr daxilində təqdim edir. Bu proses kommunikasiya nəzəriyyəsində framing (çərçivələmə) kimi xarakterizə olunur və informasiya seçimi, vurğulama və interpretasiya mexanizmləri vasitəsilə auditoriyanın qavrayışını istiqamətləndirir.

Tədqiqatın nəzəri-metodoloji bazasını Teun A. van Dijk tərəfindən inkişaf etdirilmiş sosiokoqnitiv Kritik Diskurs Analizi modeli və George Lakoff və Mark Johnson tərəfindən irəli sürülmüş Konseptual Metafora Nəzəriyyəsi təşkil edir. Van Dijk diskursu sosial strukturlar və koqnitiv proseslər arasında vasitəçi mexanizm kimi şərh edərək, media mətnlərinin ideoloji güc münasibətlərinin yenidən istehsalında rolunu vurğulayır. Lakoff və Johnson isə metaforanı yalnız üslubi vasitə deyil, insan düşüncəsini strukturlaşdıran fundamental koqnitiv mexanizm kimi izah edirlər. Siyasi diskursda "müharibə", "oyun", "teatr" və "orqanizm" kimi konseptual metaforalar

mürəkkəb sosial və siyasi proseslərin daha anlaşıqlı və interpretativ çərçivələrdə təqdim olunmasına xidmət edir (Cap, 2023, s. 155−178). Mövcud elmi ədəbiyyatda media diskursu geniş şəkildə tədqiq olunsa da, qlobal və regional media mətnlərində eyni siyasi hadisələrin fərqli diskursiv strategiyalarla təqdim olunması və bunun linqvo-koqnitiv nəticələri hələ də kifayət qədər müqayisəli şəkildə araşdırılmamışdır. Bu baxımdan, təqdim olunan tədqiqat mövcud elmi boşluğu doldurmağa yönəlmişdir.

Tədqiqatın əsas məqsədi beynəlxalq və regional media diskurslarında qlobal siyasi proseslərin və geosiyasi münaqişələrin təqdimatında istifadə olunan praqmalingvistik manipulyasiya strategiyalarını, ideoloji leksik seçimləri və dominant konseptual metafora modellərini müqayisəli şəkildə təhlil etməkdir. Eyni zamanda, bu dil vasitələrinin ictimai şüur, kollektiv yaddaş və siyasi qavrayış üzərində yaratdığı sosiokoqnitiv və psixolinqvistik təsirlərin müəyyən edilməsi də tədqiqatın əsas analitik istiqamətlərindən biridir.

Metodlar

2.1. Tədqiqat materialı və empirik baza

Tədqiqatın empirik bazasını 2024–2026-cı illəri əhatə edən xronoloji çərçivədə qlobal siyasi-iqtisadi hadisələrə, beynəlxalq münasibətlər sistemində baş verən transformasiyalara və regional geosiyasi böhranlara dair aparıcı beynəlxalq media resurslarından (BBC, CNN, Reuters) və dövlət rəsmilərinin rəsmi bəyanatlarından seçilmiş 150-dən çox genişhəcmli analitik və xəbər mətni təşkil edir. Korpusun formalaşdırılması zamanı elmi obyektivlik, təmsilçilik (representativeness) və diskursiv müxtəliflik prinsipləri əsas götürülmüşdür (Charteris-Black, 2018).

Mətnlərin seçilməsində aşağıdakı kriteriyalar tətbiq edilmişdir:
(i) tematik uyğunluq – qlobal siyasi, iqtisadi və geosiyasi proseslərin əhatə olunması;
(ii) janr müxtəlifliyi – xəbər materialları (hard news), analitik icmallar, ekspert şərhləri və redaksiya məqalələrinin daxil edilməsi;
(iii) temporal ardıcıllıq – 2024-cü ilin yanvarından 2026-cı ilin birinci rübünə qədər olan dövrün əhatə olunması.
Toplanmış materiallar təxminən 120.000 sözdən ibarət korpus şəklində sistemləşdirilmişdir. Korpus mövzu, janr, ideoloji istiqamət və temporal xüsusiyyətlər üzrə kateqoriyalaşdırılmış, daha sonra diskursiv və semantik analiz üçün inteqrativ metodoloji yanaşma tətbiq edilmişdir. Tədqiqatda həm keyfiyyət (qualitative), həm də qismən kəmiyyət (quantitative) analiz metodlarından istifadə olunmuşdur.

2.2. Kritik diskurs analizi

Diskursdakı institusional güc münasibətlərini, ideoloji yönləndirməni və implicit qərəzliliyi müəyyən etmək üçün Teun A. van Dijk-in sosiokoqnitiv Kritik Diskurs Analizi (CDA) modeli tətbiq edilmişdir. Bu yanaşma diskursu sosial struktur və koqnitiv proseslərin qarşılıqlı əlaqəsi kimi izah edir (Fairclough, 2023). Analiz zamanı mətnlər makrostruktur və mikrostruktur səviyyələrində təhlil edilmişdir. Makrostruktur səviyyədə diskursun tematik çərçivəsi və ideoloji istiqaməti, mikrostruktur səviyyədə isə leksik seçimlər, sintaktik konstruksiyalar və praqmatik strategiyalar araşdırılmışdır.

Tədqiqatda Van Dijk-in “ideoloji kvadrat” modeli əsas analitik çərçivə kimi istifadə edilmişdir. Bu model diskursda “biz” və “onlar” qarşıdurmasının aşağıdakı strategiyalarla qurulduğunu izah edir:
- daxili qrupun müsbət təqdimatı
- xarici qrupun mənfi təqdimatı
- daxili qrupun mənfi xüsusiyyətlərinin minimallaşdırılması
- xarici qrupun müsbət xüsusiyyətlərinin gizlədilməsi

Diskursiv analizdə nominalizasiya, passiv konstruksiyalar, emosional leksika və evaluativ ifadələr kimi dil mexanizmləri sistemli şəkildə kodlaşdırılmışdır. Eyni zamanda framing, agenda-setting və legitimləşdirmə strategiyaları da təhlil olunmuşdur.

2.3. Konseptual metafora analizi

Siyasi və ideoloji diskursun koqnitiv strukturlarını müəyyən etmək üçün George Lakoff və Mark Johnson-un Konseptual Metafora Nəzəriyyəsi tətbiq edilmişdir. Bu yanaşmaya əsasən metafora yalnız dil vasitəsi deyil, həm də düşüncə və qavrayışın strukturlaşdırıcı mexanizmidir. Metaforik ifadələrin identifikasiyası Pragglejaz Group tərəfindən təklif edilmiş Metaphor Identification Procedure (MIP) əsasında aparılmışdır. Bu prosedur kontekstual və əsas mənaların müqayisəsi vasitəsilə metaforik istifadənin müəyyən edilməsini təmin edir (Ganz, 2024). Daha sonra metaforalar konseptual xəritələmə (conceptual mapping) əsasında təhlil edilmişdir. Burada mənbə sahəsi (source domain) ilə hədəf sahəsi (target domain) arasında sistemli köçürmələr müəyyən edilmişdir.

Tədqiqatda xüsusilə aşağıdakı dominant metafora modelləri aşkarlanmışdır:
- Siyasət müharibədir
- Dövlət canli orqanizmdir
- İqtisadi böhran xəstəlikdir

Bu metaforik strukturların ideoloji çərçivələmə, emosional təsir və legitimləşdirmə funksiyaları yerinə yetirdiyi müəyyən edilmişdir.

2.4. Praqmalingvistik kontent-analiz

Tədqiqatda manipulyativ diskurs strategiyalarının empirik ölçülməsi məqsədilə praqmalingvistik kontent-analiz tətbiq edilmişdir. Bu yanaşma keyfiyyət və kəmiyyət metodlarının inteqrasiyasına əsaslanır. Korpus daxilində evfemizmlər, disfemizmlər, emosional yüklü leksika və modal-qiymətləndirici ifadələr funksional kateqoriyalar üzrə kodlaşdırılmışdır. Daha sonra onların tezlik göstəriciləri (absolute və relative frequency) hesablanmış və müxtəlif media platformaları üzrə müqayisəli analiz aparılmışdır. Analiz nəticəsində müəyyən edilmişdir ki, leksik seçimlər təsadüfi xarakter daşımır, əksinə sistemli ideoloji yönləndirmə və praqmatik təsir strategiyalarının tərkib hissəsi kimi fəaliyyət göstərir. Bu isə media diskursunun həm emosional, həm də ideoloji manipulyasiya funksiyasını empirik olaraq təsdiqləyir (Hart, 2023).

Nəticələr

Aparılan kompleks linqvo-koqnitiv, semantik və kritik diskurs analizləri müasir siyasi media diskursunda kütləvi şüurun formalaşdırılması, ideoloji yönləndirmə və siyasi reallığın diskursiv rekonstruksiyası ilə bağlı bir sıra sistemli qanunauyğunluqları üzə çıxarmışdır. 150-dən çox media mətnindən ibarət korpus üzərində həyata keçirilmiş keyfiyyət və kəmiyyət təhlilləri göstərir ki, media dilində istifadə olunan leksik-semantik seçimlər, sintaktik strukturlar və metaforik modellər təsadüfi xarakter daşımır, əksinə müəyyən ideoloji və kommunikativ məqsədlərə xidmət edən strukturlaşdırılmış diskursiv strategiyaların tərkib hissəsidir (Hodge & Kress, 2021).

Korpus üzrə aparılan statistik analizlər müxtəlif media platformalarında eyni hadisələrin təqdimatında semantik vurğuların, agentlik münasibətlərinin və emosional leksikanın intensivliyində əhəmiyyətli fərqlərin mövcud olduğunu göstərmişdir. Bu fərqlər əsasən "öz qrupunun legitimləşdirilməsi" və "digər qrupun delegitimləşdirilməsi" prinsiplərinə əsaslanan ideoloji qütbləşmə modelinə uyğun şəkildə təşkil olunur. Nəticələr xəbər diskursunun səthi olaraq neytral görünməsinə baxmayaraq, onun daxilində sistemli praqmatik yönləndirmə və ideoloji çərçivələmə mexanizmlərinin fəaliyyət göstərdiyini təsdiqləyir (İmanova, 2024, s. 129).

3.1. İdeoloji kvadrat və “Biz vs. Onlar” modelinin analizi

Empirik materialın təhlili daxili qrupun (in-group) müsbət təqdimatı və xarici qrupun (out-group) neqativləşdirilməsi prosesində spesifik leksik və sintaktik mexanizmlərin intensiv şəkildə tətbiq olunduğunu ortaya qoymuşdur. Xüsusilə, hadisələrin pozitiv və ya neqativ çərçivələnməsi qrammatik seçimlər, fel növləri, agentin görünürlük dərəcəsi və emosional konnotasiyalı leksika vasitəsilə sistemli şəkildə tənzimlənir. Analiz nəticələri göstərir ki, “öz tərəf”ə aid hadisələr təqdim edilərkən passiv konstruksiyalar, nominalizasiya və şəxssizləşdirilmiş sintaktik strukturlar daha çox üstünlük təşkil edir. Bu strategiya hadisənin icraedici subyektini gizlədərək məsuliyyətin qeyri-müəyyənləşdirilməsinə və emosional təsirin zəiflədilməsinə xidmət edir. Məsələn, “mülki itkilər baş verdi” tipli konstruksiyalar konkret agenti göstərmədən hadisəni strukturlaşdırır və məsuliyyətin diskursiv şəkildə diffuziyasına səbəb olur (Koller, 2021). Bunun əksinə olaraq, “digər tərəf”ə aid fəaliyyətlər daha çox aktiv sintaktik strukturlar və açıq agentlik markerləri ilə təqdim olunur. Bu kontekstdə rəqib aktorlar yüksək dərəcədə agentləşdirilmiş formada təqdim edilərək aqressiv, təhlükəli və legitimliyi şübhə doğuran subyektlər kimi çərçivələnir. Xüsusilə “hücum etmək”, “təhdid yaratmaq”, “pozmaq” və “məhv etmək” kimi yüksək neqativ semantik yükə malik feillərin sistemli istifadəsi müşahidə olunmuşdur.

Bu tapıntılar göstərir ki, ideoloji qütbləşmə yalnız məzmun səviyyəsində deyil, həm də qrammatik struktur, sintaktik təşkilatlanma və leksik-semantik seçimlər vasitəsilə diskursiv şəkildə istehsal olunur. Beləliklə, media diskursu “biz/onlar” qarşıdurmasını sadəcə təsvir etmir, eyni zamanda onu aktiv şəkildə konstruksiya edir və təkrar istehsal edir.

Korpus daxilində linqvistik asimmetriya və manipulyativ diskurs strategiyaları

Korpus analizi nəticəsində media diskursunda “biz” və “onlar” qrupları arasında sistemli linqvistik asimmetriya və ideoloji yönləndirməyə xidmət edən bir sıra manipulyativ dil mexanizmləri müəyyən edilmişdir. Bu mexanizmlər sintaktik struktur, leksik seçim və praqmatik funksiya baxımından fərqli şəkildə realizə olunur və diskursun ideoloji çərçivələnməsini gücləndirir. Aşağıdakı cədvəldə əsas dil mexanizmləri, onların “biz” və “onlar” qrupları üzrə funksional istifadəsi və korpus daxilində rastgəlmə tezlikləri sistemləşdirilmişdir:

Cədvəl 1
Korpus daxilində linqvistik asimmetriya və manipulyativ dil mexanizmləri

Dil mexanizmi	“Biz” tərəfi üzrə istifadə xüsusiyyəti	“Onlar” tərəfi üzrə istifadə xüsusiyyəti	Rastgəlmə tezliyi (%)
Passiv konstruksiyalar	Məsuliyyətin gizlədilməsi və hadisənin agentsizləşdirilməsi məqsədilə intensiv istifadə olunur	Nisbətən az istifadə olunur	34%
Nominalizasiya	Hadisələrin abstraktlaşdırılması və agentin diskursiv olaraq silinməsi	Məhdud istifadə olunur	27%
Aktiv fellər	Daha yumşaq, neytral və ya legitimləşdirici çərçivədə təqdim olunur	Aqressiv, birbaşa və yüksək agentliklə vurğulanır	41%
Emosional leksika	Müdafiə, legitimlik və rasionallaşdırma çərçivəsində formalaşır	Təhlükə, konflikt və aqressiya çərçivəsində intensivləşir	46%
Evfemizmlər	Öz tərəfin neqativ fəaliyyətlərinin yumşaldılması və neytrallaşdırılması üçün istifadə olunur	Demək olar ki, istifadə olunmur	22%

Dil mexanizmi	"Biz" tərəfi üzrə istifadə xüsusiyyəti	"Onlar" tərəfi üzrə istifadə xüsusiyyəti	Rastgəlmə tezliyi (%)
Disfemizmlər	Məhdud və nəzarətli şəkildə tətbiq olunur	Qarşı tərəfin demonizasiyası və neqativ çərçivələnməsi üçün intensiv istifadə olunur	31%

Əldə olunan nəticələr göstərmişdir ki, ideoloji qütbləşmə yalnız məzmun səviyyəsində deyil, həm də qrammatik struktur, sintaktik təşkilatlanma və semantik seçimlər vasitəsilə sistemli şəkildə qurulur. Beləliklə, "Biz vs. Onlar" modeli media diskursunda ictimai şüurun istiqamətləndirilməsi və siyasi reallığın manipulyativ şəkildə təqdim olunması üçün əsas koqnitiv çərçivələrdən biri kimi çıxış edir. Bundan əlavə, müəyyən edilmişdir ki, analitik və redaksiya məqalələrində ideoloji qütbləşmə xəbər janrı ilə müqayisədə daha yüksək intensivlik nümayiş etdirir. Xüsusilə opinion və editorial tipli mətnlərdə emosional yüklü leksikanın, metaforik konstruksiyaların və qiymətləndirici ifadələrin tezliyi təxminən 1.7 dəfə daha yüksək olmuşdur. Bu isə göstərir ki, interpretativ media janrları auditoriyanın emosional və ideoloji istiqamətləndirilməsində daha güclü manipulyativ potensiala malikdir.

3.2. Siyasi diskursda dominant konseptual metafora modelləri və koqnitiv xəritələmə

Koqnitiv-semantik analiz göstərir ki, müasir siyasi media diskursu mürəkkəb geosiyasi prosesləri, iqtisadi böhranları və beynəlxalq münasibətlərdəki qarşıdurmaları daha anlaşılan və emosional baxımdan təsirli formada təqdim etmək üçün konseptual metafora mexanizmlərindən sistemli şəkildə istifadə edir. Lakoff və Johnson-un Konseptual Metafora Nəzəriyyəsinə əsasən, abstrakt siyasi reallıqlar daha konkret və gündəlik təcrübəyə əsaslanan koqnitiv domenlər vasitəsilə strukturlaşdırılır.

Korpus analizi metaforik xəritələmələrin üç əsas dominant model ətrafında cəmləşdiyini göstərmişdir. Bu modellər yalnız dilin üslubi elementi deyil, eyni zamanda auditoriyanın siyasi reallığı qavrama çərçivəsini formalaşdıran güclü koqnitiv strukturlar kimi fəaliyyət göstərir.

1. Siyasət/diplomatiya müharibədir

Ən yüksək tezliklə müşahidə olunan metafora modeli "siyasət müharibədir" konseptual çərçivəsidir. Təhlil göstərir ki, diplomatik danışıqlar, iqtisadi razılaşmalar və beynəlxalq sanksiyalar belə hərbi leksikon və konflikt semantikası vasitəsilə çərçivələnir. Bu isə siyasi proseslərin qarşıdurma və rəqabət məntiqi əsasında qavranılmasını gücləndirir. Korpusda müəyyən edilmiş əsas metaforik ifadələrə aşağıdakılar daxildir: "sanksiya cəbhəsi", "iqtisadi hücum əməliyyatı", "ritorik atışma", "diplomatik arsenal", "geosiyasi savaş" və "məlumat müharibəsi". Bu modeldə "mənbə domeni" (source domain) hərbi qarşıdurma, "hədəf domeni" (target domain) isə diplomatiya, iqtisadiyyat və beynəlxalq münasibətlərdir. Belə xəritələmə nəticəsində siyasi hadisələr "davamlı təhlükə" və "rəqabət mühiti" kimi çərçivələnir, bu isə "biz/onlar" ikili qarşıdurmasını gücləndirir. Koqnitiv baxımdan bu metafora modeli rasional analizdən çox emosional interpretasiyanı aktivləşdirir və siyasi opponentin avtomatik şəkildə təhlükə aktoru kimi qavranılmasına şərait yaradır. Nəticədə kompromis və dialoq ehtimalı diskursiv olaraq zəiflədilir.

2. Dövlət canlı orqanizmdir

İkinci dominant metafora modeli dövlətlərin və siyasi sistemlərin canlı orqanizm kimi konseptuallaşdırılmasıdır. Bu çərçivədə siyasi və iqtisadi strukturlar insan bədəni və bioloji proseslər vasitəsilə izah olunur. Korpusda müşahidə olunan ifadələrə "Avropanın zəifləyən ürəyi", "iqtisadiyyatın iflici", "ittifaqın can çəkişməsi", "siyasi sistemin xərçəng şişi", "demokratiyanın nəfəs ala bilməməsi" və "siyasi orqanizmin çöküşü" kimi nümunələr daxildir.

Bu modeldə "mənbə domeni" insan biologiyası, "hədəf domeni" isə dövlət idarəçiliyi və beynəlxalq sistemlərdir. Xüsusilə "xəstəlik" metaforaları müəyyən siyasi aktorların delegitimləşdirilməsi və təhlükə kimi çərçivələnməsi funksiyasını yerinə yetirir. Koqnitiv səviyyədə bu metaforalar qorxu, iyrənmə və təhlükə hisslərini aktivləşdirir, nəticədə müəyyən aktorların "müalicə edilməli problem" kimi qəbul olunması diskursiv şəkildə legitimləşdirilir.

3. Siyasi proses oyundur/teatrdır

Üçüncü dominant model siyasi hadisələrin oyun, teatr və səhnə metaforaları vasitəsilə təqdim edilməsidir. Bu çərçivədə qlobal münaqişələr və diplomatik proseslər strateji oyun və ya performativ səhnə kimi təsvir olunur. Korpusda "pərdəarxası sövdələşmələr", "geosiyasi gediş", "siyasi ssenari", "Vaşinqtonun növbəti addımı", "beynəlxalq səhnədə rol bölgüsü" və "diplomatik tamaşa" kimi ifadələr müəyyən edilmişdir. Bu modeldə "mənbə domeni" oyun və teatr konseptləri, "hədəf domeni" isə siyasi və beynəlxalq proseslərdir. Bu çərçivələmə nəticəsində ciddi siyasi hadisələr estetikləşdirilir və tamaşa xarakteri qazanır. Koqnitiv təsir baxımından bu metafora modeli auditoriyanın hadisələrə aktiv vətəndaş mövqeyindən deyil, passiv müşahidəçi mövqeyindən yanaşmasına səbəb olur. Beləliklə, sosial məsuliyyət hissi zəifləyir və siyasi proseslər "strateji oyun" kimi normallaşdırılır.

Müzakirə

Aparılan tədqiqatın empirik və nəzəri nəticələri göstərir ki, media diskursunun təhlilində koqnitiv dilçilik, siyasi dilçilik və kritik diskurs analizinin inteqrativ tətbiqi latent ideoloji yönləndirmə və institusional güc münasibətlərinin aşkara çıxarılmasında yüksək metodoloji effektivliyə malikdir. Əldə olunan nəticələr Teun van Dijk-in sosiokoqnitiv modelinə əsaslanan diskurs nəzəriyyəsini empirik səviyyədə təsdiqləməklə yanaşı, onu genişləndirir və media dilinin sosial nəzarət və ideoloji reproduksiya mexanizmi kimi fəaliyyətini daha aydın şəkildə nümayiş etdirir. Tədqiqat göstərir ki, media mətnlərindəki dil vahidləri təsadüfi kommunikativ seçimlər deyil, ictimai şüurun strukturlaşdırılması və kollektiv idrak modellərinin yönləndirilməsi üçün sistemli şəkildə təşkil olunmuş diskursiv strategiyalardır. Bu yanaşma ənənəvi struktur dilçilik çərçivələrindən fərqli olaraq, leksik və sintaktik seçimlərin yalnız üslubi funksiyaya malik olmadığını, eyni zamanda koqnitiv reallığın formalaşmasında aktiv rol oynadığını ortaya qoyur.

Lakoff və Johnson-un konseptual metafora nəzəriyyəsinə uyğun olaraq müəyyən edilmişdir ki, metaforik konstruksiyalar auditoriyanın hadisələri interpretasiya etmə çərçivəsini formalaşdıran əsas koqnitiv strukturlar kimi çıxış edir. Oxucu media diskursunu qəbul edərkən bu çərçivələr daxilində düşünməyə yönləndirilir və nəticədə alternativ interpretasiya imkanları məhdudlaşır. Beləliklə, media tərəfindən təqdim edilən ideoloji model dominant koqnitiv reallıq kimi institusionallaşır.

Empirik analizlər xüsusilə "xəstəlik", "təhlükə" və "təbii fəlakət" metaforalarının sistemli və yüksək intensivliklə istifadə olunduğunu göstərmişdir. "Virus", "xərçəng", "epidemiya", "miqrant seli" və "siyasi sunami" kimi metaforik konstruksiyalar siyasi aktorları təhlükəli və qeyri-legitim subyektlər kimi çərçivələyərək auditoriyada qorxu və təhlükə qavrayışını gücləndirir. Bu isə emosional reaksiyaların rasional siyasi analiz üzərində üstünlük qazanmasına səbəb olur və müəyyən aktorların sosial və siyasi sistemdən kənarlaşdırılmasını diskursiv şəkildə legitimləşdirir. Bu nəticələr göstərir ki, media diskursu yalnız informativ funksiya daşımır, eyni zamanda siyasi və sosial reallığın aktiv şəkildə yenidən istehsal olunduğu ideoloji bir sahə kimi çıxış edir. Bundan əlavə, manipulyativ diskurs strategiyalarının yalnız qlobal media institutlarına deyil, həm də regional və lokal media strukturlarına xas olması müəyyən edilmişdir. Bu isə sosiokoqnitiv çərçivələmə mexanizmlərinin universal xarakter daşıdığını göstərir.

Nəticə

Əldə olunan nəticələr müasir media mühitində obyektivlik və neytrallıq haqqında ənənəvi yanaşmaların yenidən nəzərdən keçirilməsinin vacibliyini ortaya qoyur. Rəqəmsal informasiya mühitində diskursun ideoloji yükünün daha gizli və çoxqatlı formalarda təzahür etməsi auditoriyanın media savadlılığı və tənqidi düşünmə bacarıqlarının inkişafını zəruri sosial ehtiyac kimi aktuallaşdırır.

4.1. Tədqiqatın məhdudiyyətləri və gələcək perspektivlər

Hər bir empirik tədqiqatda olduğu kimi, bu araşdırmanın da müəyyən metodoloji və struktur məhdudiyyətləri mövcuddur. Bu məhdudiyyətlərin qeyd olunması nəticələrin interpretasiya çərçivəsini dəqiqləşdirmək və elmi obyektivliyi təmin etmək baxımından əhəmiyyətlidir.

Birinci məhdudiyyət tədqiqat korpusunun əsasən yazılı media materialları (onlayn xəbər mənbələri, analitik məqalələr və rəsmi bəyanatlar) üzərində qurulması ilə bağlıdır. Bu səbəbdən vizual və audiovizual diskurs elementləri, o cümlədən televiziya çıxışları, sosial media videoları və multimodal propaganda materialları təhlil xaricində qalmışdır.

İkinci məhdudiyyət tədqiqatın 2024–2026-cı illərlə məhdudlaşdırılmış temporal çərçivəsidir. Bu isə media diskursunda uzunmüddətli tarixi dəyişikliklərin və ideoloji transformasiyaların diaxron analizini məhdudlaşdırır. Gələcək tədqiqatlar daha geniş zaman kəsiyini əhatə etməklə diskursiv dəyişmə dinamikasını daha sistemli şəkildə izah edə bilər.

Müasir rəqəmsal media mühitinin multimodal xarakteri nəzərə alındıqda, diskurs artıq yalnız verbal komponentlərlə məhdudlaşmır. Mətn, vizual elementlər, rəng kodları, qrafik struktur, musiqi və video materiallar vahid semiotik sistem daxilində fəaliyyət göstərir və bu da manipulyativ təsirin gücünü artırır. Bu baxımdan gələcək tədqiqatlarda Gunther Kress və Theo van Leeuwen tərəfindən inkişaf etdirilmiş vizual semiotik analiz və multimodal diskurs analizi yanaşmalarının tətbiqi xüsusi əhəmiyyət kəsb edir. Bu yanaşmalar media manipulyasiyasının yalnız verbal deyil, eyni zamanda vizual və multimodal səviyyələrdə necə qurulduğunu daha dərin şəkildə izah etməyə imkan verə bilər.

Bundan əlavə, süni intellekt əsaslı təbii dil emalı (NLP), korpus linqvistikası və böyük verilənlər analitikası metodlarının tətbiqi media diskursunda manipulyativ strategiyaların avtomatlaşdırılmış identifikasiyası üçün yeni elmi imkanlar yaradır. Bu istiqamət gələcək tədqiqatlarda daha geniş miqyaslı, müqayisəli və statistik əsaslı diskurs analizlərinə şərait yaradacaqdır.

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Hungary's Geopolitical Strategy in the Context of the European Union and the Organization of Turkic States: National Interests, Roles, and Implications (The Orbán Era, 2010–2026)

Mahsa Mehdizadeh Youshanlouei

Abstract. *This study analyzes Hungary's foreign policy orientation between 2010 and 2026 within the framework of its positioning between the European Union (EU) and the Organization of Turkic States (OTS). It examines Hungary's "Eastern Opening" (Keleti Nyitás) policy as a multidimensional strategy that integrates economic pragmatism with identity-based foreign policy narratives. By combining hedging theory and constructivist approaches, the study explains how Hungary maintains its institutional embeddedness within Western structures while simultaneously expanding its external partnerships toward Eurasian actors. The findings indicate that Hungary seeks to preserve the economic and institutional benefits of EU membership while increasing its strategic autonomy through engagement with the OTS and broader Eastern networks. Energy security, economic diversification, and geopolitical positioning constitute the main pillars of this strategy. Historical and cultural narratives, particularly Turanism, operate as legitimizing identity frameworks that reinforce Hungary's eastward-oriented diplomatic engagement.*

Keywords: *Hungary, European Union, Organization of Turkic States, hedging strategy, Eastern Opening, foreign policy, Turanism*

Ankara Hacı Bayram Veli University, Ankara, Turkey
E-mail: mehdizademehsa@gmail.com
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Avropa İttifaqı və Türk Dövlətləri Təşkilatı Kontekstində Macarıstanın geosiyasi strategiyası: Milli maraqlar, rollar və nəticələr (Orban Dövrü, 2010–2026)

Mahsa Mehdizadə Youşanlouei

Xülasə. *Bu tədqiqat Macarıstanın 2010–2026-cı illər üzrə xarici siyasət istiqamətlərini Avropa İttifaqı (Aİ) və Türk Dövlətləri Təşkilatı (TDT) müstəvisində təhlil edir. Araşdırma göstərir ki, Macarıstanın "Keleti Nyitás" (Şərqə açılım) siyasəti çərçivəsində formalaşdırdığı çoxvektorlu xarici siyasət strategiyası yalnız iqtisadi praqmatizmə deyil, eyni zamanda kimlik əsaslı amillərə də söykənir. Hedging (risklərin balanslaşdırılması) yanaşması ilə konstruktivist nəzəriyyə birləşdirilərək, Macarıstanın Qərb institutları ilə inteqrasiyanı davam etdirərkən Şərq yönümlü alternativ əməkdaşlıqlar inkişaf etdirdiyi göstərilir. Nəticələr göstərir ki, Macarıstan Aİ üzvlüyü vasitəsilə iqtisadi və institusional qazancını qoruyarkən, TDT və Avrasiya mərkəzli əlaqələr vasitəsilə strateji çeviklik imkanlarını genişləndirir. Enerji təhlükəsizliyi, iqtisadi diversifikasiya və geosiyasi mövqelənmə bu strategiyanın əsas komponentləri kimi ön plana çıxır.*

Turanizm və tarixi-mədəni diskurslar isə xarici siyasət seçimlərini legitimləşdirən kimlik çərçivələri kimi çıxış edir.

Açar sözlər: *Macarıstan, Aİ, TDT, hedging, Keleti Nyitás, xarici siyasət, Turanizm*

Ankara Hacı Bayram Vəli Universiteti, Ankara, Türkiyə
E-poçt: mehdizademehsa@gmail.com
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Introduction

Situated at the center of Central Europe, Hungary has historically maintained a multi-layered foreign policy tradition positioned between East and West. Historical and cultural narratives referring to Hun and Central Asian connections, the geopolitical legacy of the Austro-Hungarian Empire, and the post–Cold War integration process with Western institutions collectively reveal the multidimensional character of the country's foreign policy identity. This study examines these foreign policy dynamics within the temporal scope of the Orbán era (2010–2026). In particular, the "Opening to the East" (*Keleti Nyitás*) policy implemented by the Fidesz government since 2010 has enabled Hungary to diversify its relations with alternative regional and global actors while maintaining its membership in the European Union. In this context, engagements with the Organization of Turkic States (OTS) constitute a significant dimension of Hungary's multi-vector foreign policy orientation. The Informal Summit of the OTS held in Budapest in 2025 can be considered a notable example in which Hungary's multidirectional foreign policy orientation gained visibility. The organization of the summit in an observer country for the first time contributed to the increasing prominence of Hungary's self-positioning as a "bridge country" at the international level. However, the extent to which this discourse corresponds to an institutionalized and strategic foreign policy orientation remains a contested issue in the academic literature.

The primary aim of this study is to analyze the nature of the foreign policy balance between Hungary's European Union membership and its relations with the Organization of Turkic States. This analysis is confined to the Orbán period (2010–2026). Within this framework, the research investigates whether this dual orientation constitutes a complementary strategy in terms of national interests (energy security, economic diversification, and foreign policy autonomy) or generates structural tensions between the normative framework of the European Union and the eastern opening. The geopolitical transformation following the Russia–Ukraine War has made Hungary's foreign policy choices more visible and contentious.

This study approaches Hungarian foreign policy not merely through a European Union–centric explanatory framework but as a multi-vector and multi-actor strategy. In this regard, it focuses on elements such as energy geopolitics, economic diversification, and strategic autonomy, analyzing the flexible foreign policy strategies developed by middle powers within a changing international system. Furthermore, the study aims to provide an integrated theoretical framework by combining identity-based approaches with rational choice and hedging literature. Within this scope, Turanism is considered as a historical-cultural reference embedded in Hungarian foreign policy discourse, while the hedging strategy is employed as an analytical tool to explain how states develop multidirectional foreign policies by distributing risks in an uncertain international system. This integrated approach allows for a more comprehensive analysis of Hungary's foreign policy behavior by incorporating both material interests and identity-based factors.

Unlike the existing literature, which predominantly examines Hungary's foreign policy within the framework of European Union–centered normative debates, this study analyzes the country's multi-vector foreign policy strategy through a comparative perspective along the axes of the European Union (EU) and the Organization of Turkic States (OTS). In this respect, the study evaluates Hungary's foreign policy not as confined to a single regional or institutional framework but through simultaneous networks of interaction between East and West. In the literature, Hungary's foreign policy is generally addressed in the context of normative deviation within the EU, rule of law debates, or relations with Russia. In contrast, this study incorporates Hungary's relations with the Organization of Turkic States into the analysis, positioning the country's foreign policy behavior within a broader geopolitical network. This perspective opens up the question of whether Hungary's "bridge country" discourse is merely rhetorical or represents a strategic foreign policy orientation.

Another original contribution of this study is the integration of two theoretical approaches that are often treated separately in international relations literature. By combining the hedging strategy with the constructivist identity approach, Hungary's foreign policy behavior is explained through both material interests (energy security, economic diversification, strategic autonomy) and identity-based factors (historical narratives, Turanism, and East–West discourse). This integrated framework moves beyond one-dimensional explanatory models of state behavior and offers a more comprehensive analytical perspective. Finally, the study provides an empirical contribution to the literature on flexible foreign policy strategies developed by middle powers in a multipolar international system. Through the case of Hungary, it demonstrates that small and medium-sized states are not merely dependent actors on great powers but can also act as strategic actors capable of developing multidirectional foreign policy tools.

Methods

This study is designed within a qualitative research framework and employs the single-case study method (Yin, 2018) to conduct an in-depth analysis of Hungary's foreign policy behavior. The scope of the analysis is limited to the Orbán period between 2010 and 2026. The case study method is preferred due to its capacity to examine complex political processes contextually and to provide in-depth answers to "how" and "why" questions. The case under investigation is Hungary's post-2010 foreign policy orientation developed along the axes of the European Union (EU) and the Organization of Turkic States (OTS). This case selection provides an analytically unique example, as Hungary simultaneously participates in institutional European integration while developing relations with alternative regional cooperation networks.

Analytical Framework

The research is based on the integration of two complementary theoretical approaches:

- **Hedging approach:** Argues that states develop multidirectional and flexible foreign policy behaviors instead of relying on single-alignment strategies in response to uncertainties in the international system.
- **Constructivist approach:** Suggests that state behavior is shaped not only by material interests but also by identity, historical memory, and discursive structures.

The combined use of these approaches enables the analysis of Hungary's foreign policy behavior in both its rational and identity-based dimensions.

Data Collection Method

The study utilizes three main data sources:
1. **Official documents:** European Union reports, statements of the Hungarian Ministry of Foreign Affairs, and declarations of the Organization of Turkic States
2. **Academic literature:** Peer-reviewed journal articles and scholarly books
3. **Discourse data:** Official speeches and statements of key decision-makers, particularly Viktor Orbán and Péter Szijjártó
This dataset enables a multidimensional analysis at both institutional and discursive levels.

The collected data are analyzed using qualitative content analysis and discourse analysis techniques. The following thematic categories are identified during the analysis process:
- National interests (energy security, economic diversification, strategic autonomy)
- Identity and historical references (Turanism, East–West discourse)
- Institutional alignment and areas of tension (EU normative framework)
- Alternative regional orientations (relations with the OTS)

To enhance the validity of the findings, the method of data triangulation is employed.

As the study is based on a single-case analysis, the statistical generalizability of the findings is limited. However, the primary aim of the research is not generalization but to provide theoretical explanatory power and conceptual depth.

Theoretical Framework

Europeanism and Turanism: Dual Identity Construction

Hungary's geopolitical identity historically exhibits a dichotomous yet flexible and reproducible structure shaped along the East–West axis. In this context, Europeanism and Turanism emerge as two principal reference frameworks that constitute the identity-based foundations of Hungarian foreign policy. Europeanism represents a historical and institutional identity reflecting Hungary's integration with the West. Its origins date back to the adoption of Christianity in 1000 AD and the Western alliance symbolized by the Crown of St. Stephen. The legacy of the Austro-Hungarian Empire and, more notably, accession to the European Union in 2004 contributed to the institutional consolidation of this identity. Europeanism provides a normative framework shaped by liberal democratic values, the rule of law, and Europe-centered institutional belonging. However, during the Orbán era (2010–present), while democratic legitimacy has been maintained, partial divergence from EU norms has emerged in areas such as judicial independence, media pluralism, and the rule of law. In the literature, this situation is interpreted as a reflection of structural tensions between Hungary's normative obligations within the EU and its prioritization of national sovereignty (Pala, 2026, pp. 18–20).

Turanism, while representing an alternative and complementary dimension of Hungarian identity, also constitutes an ideational element that provides Hungary with a distinct sphere of maneuver within European political geography. Its historical roots can be traced to the late 18th and early 19th centuries, shaped by the rediscovery of Persian literature in Western Europe. The concept of "Turan" originally referred to a geographical term in Old Persian denoting the lands inhabited by nomadic peoples north of Iran; it later acquired an ideological dimension when Max Müller introduced the term "Turanian" into scientific literature in 1861 to describe the Ural-Altaic language family. In the Hungarian context, Turanism emerged as part of the 19th-century wave of nationalism and functioned as a defensive ideology against the rising threats of Pan-Germanism and Pan-Slavism. Hungarian intellectuals sought to synthesize Finno-Ugric origins with the Hun-Turkic historical legacy in response to perceptions of linguistic and ethnic isolation. Among the pioneers of this intellectual movement, Ármin Vámbéry (1832–1913), considered the founder of Hungarian Turkology,

emphasized historical and cultural ties with Central Asian Turkic peoples in his scholarly work, while Ferenc Pulszky introduced the term "Turan" into Hungarian literature in 1839 as a geographical concept. In 1895, Géza Nagy further systematized this framework by associating "Turanian" with Ural-Altaic peoples, thereby establishing a scholarly basis for linking Hungarians to the nomadic heritage of Hun, Cuman, Tatar, and Turkic origins (Kowalczyk, 2017, pp. 49–63). Turanism acquired an institutional character with the establishment of the Turan Society (*Turáni Társaság*) in 1910. Its first president was geographer and politician Pál Teleki, and its membership included prominent figures of the Hungarian elite. The primary aim of the society was to overcome perceptions of Hungary's "linguistic and ethnic isolation" within Europe, strengthen kinship ties with Ural-Altaic peoples at scientific, cultural, and political levels, and construct an alternative sense of belonging (Akçalı & Korkut, 2012, pp. 600–602). While supporting scientific Turanological studies, the society also represented an eastern-oriented version of Hungarian nationalism. The transformation of Turanism into a political and socially revisionist ideology accelerated particularly after the Treaty of Trianon in 1920. The loss of approximately two-thirds of Hungary's territory and the displacement of more than three million ethnic Hungarians outside national borders generated a profound traumatic memory, turning Turanism into a protest ideology against a perceived "abandonment" by the West (Arıkanlı, 2017, p. 232).

During the Orbán era, the government has instrumentalized Turanist discourse as a strategic tool and political myth. Orbán's references in OTS summits to "descendants of Attila" and adherence to "Kipchak-Turkic principles" illustrate, from a constructivist perspective, the pragmatic construction of national identity (Pala, 2026, pp. 30–35).

Hedging Theory: The Balancing Strategy of Small and Middle Powers

Hedging theory refers to a foreign policy strategy developed by small and middle-sized states to minimize risks, achieve strategic autonomy, and avoid excessive dependence in an environment of great power competition and uncertainty within a multipolar international system (Kuik, 2021, p. 302). According to Kuik's conceptual framework, hedging is defined as an "insurance-seeking behavior," whereby states simultaneously pursue policies aimed at maximizing returns (*return-maximizing*) while taking precautionary measures against potential risks (*risk-contingency*). The core elements of hedging include:

- **Limited bandwagoning and soft balancing:** Preserving room for maneuver by avoiding unconditional alignment with major powers.
- **Economic pragmatism and diversification of linkages:** Maintaining balanced trade, energy, and diplomatic relations across different centers of power (Kuik, 2021, p. 312).

Hungary presents a typical example of a hedging strategy within the European context. While maintaining its EU and NATO membership and thereby engaging in "limited bandwagoning" with the Western alliance, Hungary simultaneously deepens its ties with Russia, China, and the Organization of Turkic States to enhance its strategic autonomy (Salamon, 2025, pp. 56–58). In the energy domain, the import of Azerbaijani gas and involvement in Middle Corridor projects play a critical role in reducing asymmetric dependence on Russia (Gale, 2023). In the post–Russia–Ukraine War period, this strategy has assumed a more cautious and defensive character. Hungary resists certain EU sanctions while positioning the OTS as an alternative platform, yet refrains from abandoning the Western alliance altogether (Szerencsés, 2025, pp. 6–7).

Theoretical Synthesis: Integration of Identity and Pragmatism

In the Hungarian case, the hedging strategy manifests as a foreign policy behavior intertwined with geopolitical identity (Europeanism–Turanism). While Europeanism represents Western integration, Turanism emphasizes Eastern cultural heritage and provides ideological legitimacy for relations with

the OTS. This dual structure strengthens the ideological foundation of hedging. Hungary distributes risks through eastern-oriented economic and cultural cooperation while maintaining its ties with the West. Turanist discourse renders the eastern opening "natural" by grounding it in historical narratives, thereby enabling what Alexander Wendt (1992) conceptualizes as the "social construction of national interest" (as cited in Pala, 2026, pp. 130–135).

In conclusion, Hungary's EU integration and its observer status in the OTS constitute a dual strategy shaped by the interaction of identity and pragmatism. This synthesis provides a robust theoretical foundation for understanding how the *Keleti Nyitás* policy has been sustained despite normative tensions with the EU.

Analysis of the "Keleti Nyitás" (Opening to the East) Policy: Strategic and Economic Dimensions

The "Keleti Nyitás" policy, formalized with the rise to power of the Fidesz government under Viktor Orbán during the period from 2010 to the present, has shifted Hungary's traditionally West-centered foreign policy structure toward a multi-vector and pragmatic geopolitical axis. This policy represents not merely a foreign trade strategy but also a strategic redefinition of Hungary's national position within the global system (Greilinger, 2023, p. 12).

Economic Pragmatism and Global Financial Vulnerabilities

The primary driving force behind the policy has been the profound economic shock experienced in the European periphery following the 2008 global financial crisis, alongside the growing critical perception of the European Union's crisis management capacity. Hungarian decision-makers have aimed to reduce asymmetric dependence on Western markets by developing balanced economic partnerships with China, Russia, and the Organization of Turkic States (Szerencsés, 2025, p. 5). In this context, *Keleti Nyitás* has been interpreted as a form of "financial hedging" strategy aimed at enhancing the resilience of the Hungarian economy. While in its initial phase the policy primarily reflected an economic opening centered on China and Russia, it entered a new phase after 2018 with the deepening of institutional relations with the Organization of Turkic States (OTS). Hungary's acquisition of observer status in the Turkic Council (now the OTS) in 2018 and the opening of the OTS Representation Office in Budapest in 2019 are considered key milestones in this institutional transformation (Topuz, 2024, p. 56).

Energy Security: The Trans-Caspian Middle Corridor and Strategic Partnerships

One of the most significant areas of implementation of the *Keleti Nyitás* policy is the strategy of energy diversification. The energy crisis triggered by the Russia–Ukraine War has made Hungary's high dependence on Russian hydrocarbons more visible and has elevated energy security to a strategic priority (Szerencsés, 2025). In this context, member states of the Organization of Turkic States—particularly Azerbaijan and Kazakhstan—have emerged as key partners in Hungary's energy supply diversification strategy. Within the framework of energy cooperation with Azerbaijan, a reported framework agreement between SOCAR and the Hungarian energy company MVM ONEnergy aims to increase natural gas supply over a specified period. Such initiatives are considered part of a broader strategy to reduce energy dependence on Russia through the Southern Gas Corridor (Reuters, 2025). Additionally, cooperation agreements between MOL Group and SOCAR regarding oil and natural gas exploration and production activities in Azerbaijan's Shamakhi-Gobustan region have been reported (MOL Group, 2025).

The Black Sea Submarine Green Energy Corridor initiative represents a multilateral energy infrastructure project developed among Azerbaijan, Georgia, Romania, and Hungary. The project

aims to transmit renewable energy resources from the Caspian region—particularly wind and solar energy—to European energy markets via the Black Sea (Gale, 2023).

In the context of relations with Kazakhstan, discussions have emerged regarding the expansion of oil export routes through the Baku–Tbilisi–Ceyhan (BTC) pipeline and the diversification of uranium supply chains in the nuclear energy sector (Topuz, 2024, p. 18). These initiatives are largely evaluated at the level of strategic planning and negotiation. The Middle Corridor stands out as a logistical route connecting Türkiye and OTS member states via the Caspian Sea, offering an alternative to the northern route through Russia in China–Europe trade. This corridor holds the potential to position Hungary as a strategic transit and distribution hub within Eurasian logistics (Gale, 2023). These developments indicate that the energy dimension of the *Keleti Nyitás* policy during the Orbán era (2010–present) aims both to reduce dependence on Russia and to position Hungary as a regional energy and logistics hub.

Education and Cultural Diplomacy: Stipendium Hungaricum and Institutional Socialization

The *Keleti Nyitás* policy is not limited to economic and energy cooperation but is also supported by a strong soft power and cultural diplomacy mechanism. In this context, Turanist discourse finds expression at both institutional and societal levels through educational and cultural exchange programs (Hamzaoğlu, 2025, p. 20).

The main instruments in this framework include:

- **Stipendium Hungaricum Scholarship Programme:** A comprehensive international scholarship scheme that enables students—particularly from OTS member states such as Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Türkiye—to pursue higher education in Hungary. The program aims to enhance Hungary's visibility through educational diplomacy and to establish long-term human capital networks (Hamzaoğlu, 2025, p. 12).
- **OTS Representation Office in Budapest (2019):** Functions not only as a platform for diplomatic coordination but also as an institutional mechanism contributing to the development of academic, cultural, and economic networks (Topuz, 2024, p. 13).
- **Hun-Turkic Kurultaj:** A biennial event held in Bugac that renders the symbolic and cultural dimensions of Turanist discourse visible. The event can be interpreted as a performative expression of identity that contributes to the reproduction of historical and cultural ties between Hungary and the Turkic world (Akçalı & Korkut, 2012, pp. 601–609).

Results

Hungary and the European Union: Structural Conflicts and Common Interests

Since its accession to the European Union (EU) in 2004, Hungary has significantly benefited from economic integration, enhancing its infrastructure, investment capacity, and export performance through EU funds, the single market, and free trade mechanisms. However, during the Orbán era (2010–present), structural tensions have emerged at the political and normative levels with the core values of the EU. These tensions have positioned Hungary within what the literature defines as a sphere of "normative divergence" within the EU (Pala, 2026, pp. 35–38).

Main Dimensions of Structural Conflicts

Rule of law:

Criticism regarding judicial reforms, media regulations, and anti-corruption mechanisms led the European Commission to initiate Article 7 procedures and adopt decisions to suspend certain funds

(European Commission, 2026). The Hungarian government, however, frames this process as an issue of national sovereignty.

Media freedom and civil society:

Regulations affecting independent media outlets and civil society organizations have intensified debates on "democratic backsliding" within EU institutions (Végh, 2018, pp. 16–162).

Migration, minority rights, and value politics:

Policies implemented after the 2015 refugee crisis, including border control measures, the "Stop Soros" laws, and regulations concerning LGBT+ rights, have created areas of conflict with the EU's normative framework.

Common Interests and the Sustainability of Cooperation

Despite normative tensions, strong economic and institutional interdependence persists between Hungary and the EU. Hungary continues to benefit from EU cohesion funds and financial resources under the Recovery and Resilience Facility (RRF). Moreover, security cooperation within NATO and the protection of eastern borders in the context of the Russia–Ukraine War constitute shared areas of interest. Energy diversification projects, such as the Southern Gas Corridor and the Middle Corridor, partially align with the EU's strategy to reduce dependence on Russia.

This dual structure has led to Hungary being characterized in the literature as a "strategic dissenter" or an "awkward partner" within the EU (Szerencsés, 2025, p. 45). While benefiting from the economic advantages of EU membership, Hungary exhibits a distinct differentiation in areas of national sovereignty and cultural autonomy, reflecting the political dimension of its hedging strategy.

Normative Debates within the EU and the Perception of an "Awkward" Member

The most prominent area of tension in Hungary's relations with the European Union emerges at the normative and institutional levels. During the Orbán era, government policies have created structural tensions between EU core values—such as the rule of law, judicial independence, and media freedom—and Budapest's sovereignty-centered governance approach. This has led to Hungary being labeled in the literature as an "awkward partner" or "strategic dissenter" (Pala, 2026, pp. 4–8).

Article 7 Procedure and Normative Oversight Mechanisms

Normative debates became institutionalized particularly after 2018 within the framework of Article 7 of the Treaty on European Union (TEU), which represents the EU's most powerful political sanction mechanism against serious breaches of its values (European Union, 2012).

The mechanism consists of two stages:
- **Article 7(1):** A preventive mechanism activated in cases of a clear risk of breach.
- **Article 7(2):** A sanctioning phase that may extend to the suspension of voting rights in cases of serious and persistent breaches.

The procedure against Hungary was initiated following the European Parliament's Sargentini Report in September 2018, which identified concerns related to judicial independence, media freedom, and civil society. The Hungarian government framed the process as an "interference with national sovereignty" and continued to defend its model of "illiberal democracy" (Pala, 2026, pp. 35–38).

More recently, the European Parliament's November 2025 report characterized Hungary's political system as an "electoral autocracy" and recommended moving to the Article 7(2) phase (European

Parliament, 2025). However, the unanimity requirement in the European Council limits the practical applicability of this mechanism.

Economic Sanctions and Rule of Law Conditionality

Since 2020, due to the limitations of Article 7, the EU has introduced the "rule of law conditionality" mechanism (European Commission, 2020). Under this framework, Hungary's access to cohesion funds and RRF payments has been partially suspended and tied to reforms in judicial independence and anti-corruption measures (European Commission, 2026; Reuters, 2026). This development demonstrates that normative misalignment produces direct economic consequences for Hungary and that the eastern orientation under *Keleti Nyitás* has increasingly functioned as an "alternative financial balancing strategy."

Limitations of the Article 7 Mechanism

Although Article 7 is often described in the literature as the "nuclear option," in practice it remains a limited instrument of pressure due to political constraints (Schimmelfennig, 2018). In particular, the unanimity requirement for Article 7(2) makes progress difficult due to the potential veto of member states facing similar issues (Pech & Scheppele, 2017).

Economic Interdependence and Hedging Strategy

EU membership is economically critical for Hungary. The EU single market accounts for approximately 75–80% of the country's exports, attracts the majority of foreign direct investment, and supports development through structural funds (Wivel, 2020). Integration into German industrial supply chains represents one of the strongest examples of this interdependence. However, Hungary has sought to reduce its strategic dependence by diversifying its economic relations within the framework of the *Keleti Nyitás* policy. This process is conceptualized in the literature as a "hedging strategy" (Kuik, 2021; Szerencsés, 2025; Pala, 2026). Particularly in the 2022–2026 period, restrictions on access to EU funds have increased Hungary's orientation toward alternative sources of financing. In this regard, Asia-based investments—such as European production investments by Chinese firms like BYD—have attracted attention. This indicates that Hungary is creating a strategic space for maneuver through "dual dependence," maintaining economic integration with the EU while simultaneously developing relations with the East (Pala, 2026).

Security cooperation within NATO, as well as trade and border management, continues to sustain mutual interdependence between the parties (Pala, 2026, pp. 7–13). Nevertheless, as normative tensions deepen, the balance between economic integration and political autonomy becomes increasingly fragile. In this context, Hungary seeks to maintain the economic benefits of EU membership while constructing a strategic balancing space against normative pressures through its eastern-oriented relations.

Strategic Partnership with the Organization of Turkic States (OTS)

Hungary joined the Organization of Turkic States (OTS) as an observer member in 2018, and this status was institutionalized with the Baku Summit in 2019. This membership has evolved beyond a conventional observer role into a multi-layered model of cooperation encompassing political, economic, and cultural dimensions (Pala, 2026, pp. 25–30). As a member of the European Union, Hungary occupies a unique position within the OTS and seeks to utilize this platform as a bridge between East and West.

Beyond Observer Status: Political, Cultural, and Institutional Cooperation

Political Cooperation

Hungary regularly participates in OTS summits at a high level. The Informal OTS Summit held in Budapest in May 2025 is considered a significant institutional milestone, as it marked the first time an observer state hosted such a meeting. The Budapest Declaration adopted at the summit outlined objectives related to energy, transport, trade, cultural cooperation, and connectivity (Organization of Turkic States, 2025). This development has enhanced Hungary's political visibility and influence within the OTS framework.

Cultural Cooperation

Cultural diplomacy activities conducted within the framework of Turanist discourse—such as the Hun-Turkic Kurultaj, academic exchange programs, and scholarship initiatives—reflect Hungary's effort to ground its relations with the OTS not only in pragmatism but also in identity-based foundations (Hamzaoğlu, 2025, p. 18). These initiatives aim to strengthen long-term socialization processes and support the construction of mutual perceptions.

Institutional Cooperation

The opening of the OTS European Representation Office in Budapest in 2019 marked a crucial step in institutionalizing Hungary's relations with the organization. The office contributes not only to diplomatic coordination but also to the development of academic and cultural networks. Additionally, initiatives such as the Middle Corridor projects and the Turkic Investment Fund stand out as mechanisms supporting Hungary's integration into regional economic networks (Pala, 2026, p. 22).

The Role of the OTS in Energy Security and Foreign Trade

OTS member states play a complementary role in Hungary's energy security strategy. In particular, energy cooperation with Azerbaijan represents a concrete example of Hungary's hedging policy aimed at balancing its dependence on Russia. An agreement reportedly signed in December 2025 between MVM ONEnergy and SOCAR foresees the purchase of a total of 800 million cubic meters of natural gas over a two-year period (Reuters, 2025; MVM, 2025). Such agreements involve not only supply diversification but also indirect participation in production projects in Azerbaijan. However, the literature emphasizes that Russia continues to maintain a dominant position in Hungary's energy structure and that alternative sources have not yet reached a fully substitutive level (Szerencsés, 2025, p. 21). Therefore, energy cooperation with OTS countries is better understood as a tool of strategic diversification rather than a short-term transformation. In terms of foreign trade, although the share of OTS countries in Hungary's total trade remains relatively limited, increasing economic relations with Türkiye and Central Asia are considered part of a long-term market diversification strategy (Hasan & Topuz, 2025, p. 60).

Evaluating the Equation through the Lens of National Interests and the Debate on the "Bridge Role"

Hungary's integration with the European Union and its relations with the Organization of Turkic States are fundamentally shaped by three core axes of national interest: energy security, economic diversification, and strategic autonomy. Within this framework, Hungary's foreign policy orientation can be interpreted not as an ideological preference but as a hedging strategy based on a rational search for balance (Kuik, 2021, p. 302).

This multi-vector structure enables Hungary to maintain its economic integration within the EU while simultaneously developing alternative eastern-oriented partnerships. However, it also compels the country to continuously navigate a delicate balance between "normative alignment" and "strategic autonomy."

Energy Geopolitics and the Strategic Position of Caspian Resources

Energy security constitutes one of the most decisive elements of Hungarian foreign policy. Historical and infrastructural dependence on Russia has driven Budapest to develop alternative supply channels aligned with the European Union's energy diversification policies. In this context, Azerbaijan and Caspian Basin resources play a critical role both for the EU's supply security and Hungary's risk management strategy. The Southern Gas Corridor represents a key route for delivering Caspian gas to European markets, positioning Hungary as a potential transit and distribution actor within this system (Weiner, 2024, p. 75). Furthermore, energy cooperation between MOL Group and SOCAR functions not as a complete substitute for Russian dependence but as a complementary mechanism that mitigates and diversifies this dependence (Szerencsés, 2025, p. 21). The Middle Corridor (Trans-Caspian transport route) enhances Hungary's geoeconomic significance not only in energy transport but also in trade and logistics connectivity. However, infrastructural limitations, regional instabilities, and Russia's continued influence in the energy system indicate that this process represents controlled risk diversification rather than a radical shift (Pala, 2026, pp. 125–127).

Economic Diversification: Eastern Markets and Alternative Investment Ecosystem

The economic dimension of the *Keleti Nyitás* policy is shaped by the objectives of market diversification and access to alternative investment sources. While the European Union market remains the backbone of the Hungarian economy, Budapest seeks to reduce vulnerabilities associated with one-sided economic dependence. Economic relations with Türkiye and OTS countries play an important role in diversifying trade networks. Although their share in total trade remains limited compared to the EU, the upward trend signals a long-term strategic orientation (Szerencsés, 2025, p. 28). Meanwhile, China and Asia-based investments have become increasingly influential in Hungary's economic transformation. Large-scale investments such as BYD's electric vehicle plant in Szeged and CATL's battery factory in Debrecen contribute to enhancing the country's industrial capacity and strengthening its integration into global production chains (Salamon, 2025, pp. 128–134). These developments increase Hungary's flexibility in economic decision-making but also demonstrate that the eastern opening does not fully substitute its structural economic dependence on the EU.

The Debate on the "Bridge Role": Strategic Claim and Structural Constraints

The concept of a "bridge role" in Hungarian foreign policy serves to both legitimize the country's differentiated position within the EU and frame its eastern relations within a strategic narrative.

Strategic Dimensions of the Bridge Role

Hungary's bridge role is articulated across three main levels:

- **Geoeconomic level:** The ambition to become a transit hub for trade and energy flows along the East–West axis through the Middle Corridor and energy networks
- **Diplomatic level:** The aspiration to act as a limited facilitator of dialogue between the European Union and the Organization of Turkic States
- **Cultural level:** Strengthening identity-based relations with the Turkic world through Turanist discourse

This multi-layered structure expands Hungary's foreign policy maneuverability and provides the country with a symbolic identity as a "bridge actor." However, the literature emphasizes that this role remains largely discursive and produces limited impact due to structural capacity constraints (Pala, 2026, pp. 35–38).

6.3.2. Structural Constraints from EU and OTS Perspectives

Perceptions of Hungary's bridge role differ between the European Union and the OTS:

- **European Union perspective:**

The EU approaches Hungary's eastern opening cautiously within the framework of common foreign policy alignment and normative values, thereby limiting the institutional scope of the bridge role (Pala, 2026, pp. 35–38).

- **OTS perspective:**

While OTS countries view Hungary as a potential gateway to Europe, the country's limited political weight within the EU and its normative tensions constrain the effectiveness of this role (Baranyi, 2022, pp. 34–45). Overall, Hungary's foreign policy reflects a hybrid balance model shaped by the interplay between economic integration and strategic autonomy. The "bridge role" represents both a discursive and strategic extension of this balance. However, due to existing structural constraints, it has not yet evolved into a fully institutionalized geopolitical position. Consequently, Hungary's foreign policy behavior can be characterized as a fragile and multi-layered equilibrium shaped between a "discursive bridge" and "structural dependencies."

Conclusion

This study has examined Hungary's foreign policy orientation during the 2010–2026 period within the context of its multi-layered interactions between the European Union (EU) and the Organization of Turkic States (OTS), analyzing both the structural and ideational dimensions of its multi-vector strategy. The findings demonstrate that Hungary's foreign policy behavior cannot be explained solely through short-term political preferences; rather, it should be understood as a long-term "hedging" strategy aimed at generating strategic autonomy under changing international system conditions.

First, Hungary's relations with the European Union exhibit a hybrid structure in which deep economic integration coexists with increasing normative and institutional tensions. While EU membership continues to provide significant economic advantages through access to the single market, investment flows, and structural funds, disputes over the rule of law, media freedom, and democratic norms have created a persistent line of tension between Budapest and Brussels. This situation has positioned Hungary within the EU not merely as a compliant member but as a "strategic dissenter" that periodically challenges the Union's normative framework.

Second, Hungary's eastern opening—particularly its relations with the Organization of Turkic States—is not limited to the pursuit of economic diversification. These relations are supported by material interests such as energy security, logistical integration, and access to new markets, while simultaneously gaining symbolic legitimacy through narratives of Turanism and historical-cultural kinship. This dual structure illustrates that rational calculations of interest and identity-based factors are not mutually exclusive in foreign policy behavior; rather, they reinforce one another.

Third, energy geopolitics occupies a central position in Hungary's foreign policy strategy. The structural dependence on Russia has created vulnerabilities that have driven Budapest toward alternative supply sources. In this regard, energy cooperation with Azerbaijan and the Caspian Basin,

along with Middle Corridor initiatives, has gained strategic importance. However, these alternatives have not yet reached a level capable of fully substituting the Russian energy system, functioning instead primarily as mechanisms of "risk diversification." This indicates that Hungary is pursuing a strategy of controlled balancing rather than a radical rupture in its energy policy.

Fourth, Hungary's self-positioning as a "bridge country" entails both a strategic claim to a role within the geopolitical transition zone between Europe and Asia and a process of reconstructing its foreign policy identity. However, the institutional capacity of this role remains structurally constrained by the normative boundaries of the EU and the level of institutional development within the OTS. Consequently, Hungary's bridge role appears strong at the discursive level but relatively fragile in operational terms.

In conclusion, Hungary's foreign policy experience between 2010 and 2026 demonstrates how a middle-sized state in a multipolar international system can simultaneously remain integrated within existing institutional frameworks while creating room for maneuver through alternative regional networks. In this context, Hungary seeks to preserve the economic and institutional advantages of EU membership while enhancing its foreign policy flexibility through engagement with the OTS and similar structures. However, the sustainability of this dual strategy will depend on multiple variables, including the EU's internal cohesion capacity, the level of institutionalization of Eurasian cooperation networks, and Hungary's domestic political stability.

Therefore, the Hungarian case represents not only a regional foreign policy example but also offers a significant analytical contribution to broader theoretical debates on the interaction between identity, geopolitics, and strategic autonomy.

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Technological Results Obtained Using Domestic Silkworm Genotypes in Various Seasons

Lala Abdullayeva[1], Arzu Mirzayeva[2*], Gulabatin Humbatova[1], Arzu Mammadov[3], Seyfali Kahramanov[4]

Abstract. *Since one of the primary objectives of sericulture is the production of high yields of high-quality raw silk output, any domestic silkworm line (Bombyx mori) demonstrating enhanced silk productivity is considered of significant value. Just as biological indicators reflect overall agricultural performance, technological indicators must correspond to the requirements of industrial processing. It is well established that certain biological and technological traits in silkworms are interrelated, and improvement in one group of traits often leads to corresponding enhancement in the other. For example, an increase in the cocoon shell ratio (silk content of fresh cocoons) is associated with a higher conversion efficiency from fresh to dry cocoon weight. This, in turn, results in an increased cocoon shell ratio of dry cocoons and a higher raw silk yield. In this context, the technological characteristics of the silkworm lines were evaluated. The results presented here are based on a three-year experimental study conducted under suboptimal rearing conditions across three seasonal cycles (spring, summer, and autumn). Raw silk yield from cocoons—considered the principal technological indicator of productivity—was 44.2% for the Atlas 1 line and 44.3% for the Atlas 2 line. Cocoon reelability rate (moth emergence) was relatively high in both lines, reaching 88.8% in Atlas 1 and 90.3% in Atlas 2. The filament length reeled from a single cocoon averaged 1,693 m in Atlas 1 and 1,309 m in Atlas 2. Atlas 1 line is characterized by a longer and finer filament, whereas Atlas 2 produces a thicker filament. This difference suggests that Atlas 2 may provide silk with higher mechanical strength and higher quality, while Atlas 1 yields finer and longer fibers. The metric number—an indicator of filament fineness and length—was 4,422 m/g for Atlas 1 and 3,700 m/g for Atlas 2, with higher values corresponding to finer and longer filaments. Overall, the Atlas 1 line is distinguished by a fine, long filament, a satisfactory reelability rate, and high raw silk yield. In contrast, the Atlas 2 line exhibits a thicker filament of moderate length, a high reelability rate, and similarly high silk productivity. The results of the selection experiment further indicate that maintaining both genotypes under suboptimal feeding conditions is effective.*

[1]Ganja State University, Doctor of Philosophy in Agricultural Sciences, Ganja, Azerbaijan
[2]Ministry of Science and Education of the Republic of Azerbaijan Institute of Genetic Resources, Baku, Azerbaijan
[3]Institute of Bioresources of Nakhchivan State University, Doctor of Sciences Biology, Nakhchivan, Azerbaijan
[4]Institute of Bioresources of Nakhchivan State University, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: mirzyevaa@bk.ru
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Such selective pressure enhances technological traits while improving environmental adaptability and resilience.
Keywords: *selection, line, domestic silkworm, cocoon, silk, technological indicators*

Ev ipəkqurdundan istifadə etməklə əldə edilən texnoloji nəticələr müxtəlif fəsillərdə genotiplər

Lalə Abdullayeva[1], Arzu Mirzəyeva[2*], Güləbatın Hümbətova[1], Arzu Məmmədov[3], Seyfalı Qəhrəmanov[4]

Xülasə. *İpəkçiliyin əsas məqsədlərindən biri bol və yüksək keyfiyyətli xam ipək istehsalı olduğuna görə, sınaqdan keçirilən yerli tut ipəkqurdu xətləri (cinsləri) yüksək ipək məhsuldarlığı nümayiş etdirdikdə dəyərli hesab olunur. Bioloji göstəricilər kənd təsərrüfatı məhsuldarlığını əks etdirdiyi kimi, texnoloji göstəricilər də sənaye istehsalının tələblərinə uyğun olmalıdır. Bu məqsədlə ipəkqurdlarının texnoloji xüsusiyyətləri qiymətləndirilmişdir. Qeyd etmək vacibdir ki, təqdim olunan nəticələr üç il müddətində yaz, yay və payız mövsümlərini əhatə edən və pessimal (əlverişsiz) şəraitdə aparılmış eksperimental tədqiqatlara əsaslanır. İpəkçilikdə texnoloji göstəricilər əsasında əsas məhsuldarlıq meyarı hesab olunan baramalardan alınan xam ipək çıxımı Atlaz 1 cinsi üçün 44,2%, Atlaz 2 cinsi üçün isə 44,3% təşkil etmişdir. Baramaların açılma (çıxma) qabiliyyəti üzrə Atlaz 1 cinsi 88,8% göstərici ilə nisbətən yüksək nəticə göstərmiş, Atlaz 2 cinsi isə 90,3% kimi daha yüksək qiymət nümayiş etdirmişdir. Bir baramadan açılan ipək lifinin uzunluğu Atlaz 1 cinsində 1693 metr, Atlaz 2 cinsində isə 1309 metr olmuşdur. Atlaz 1 cinsi daha nazik və uzun lifə malik olması ilə Atlaz 2 cinsindən fərqlənir, Atlaz 2 cinsinin lifləri isə daha qalındır. Bu xüsusiyyət Atlaz 2 cinsindən alınan ipək sapının keyfiyyət baxımından üstün olduğunu göstərir. Metrik nömrə—sapın naziklik və uzunluq göstəricisi—Atlaz 1 üçün 4422 m/q, Atlaz 2 üçün isə 3700 m/q olmuşdur; bu göstəricinin yüksək olması ipək sapının daha uzun və nazik olduğunu ifadə edir. Atlaz 1 cinsinin lifləri nazik və uzundur, baramaların açılma qabiliyyəti normaldır və xam ipək çıxımı yüksəkdir. Atlaz 2 cinsi isə standart uzunluğa malik daha qalın liflər, yüksək barama açılma göstəricisi və eyni dərəcədə yüksək xam ipək məhsuldarlığı ilə xarakterizə olunur. Seçmə eksperimenti nəticələri göstərir ki, hər iki genotipin pessimal (əlverişsiz) bəslənmə şəraitində saxlanılması daha səmərəlidir. Belə selektiv təzyiq təkcə ipəkqurdlarının texnoloji xüsusiyyətlərini yaxşılaşdırmır, həm də onların ekoloji uyğunlaşma qabiliyyətini və dözümlülüyünü əhəmiyyətli dərəcədə artırır.*

Açar sözlər: *seleksiya, cins, yerli tut ipəkqurdu, barama, ipək, texnoloji göstəricilər*

1Gəncə Dövlət Universiteti, kənd təsərrüfatı elmləri üzrə fəlsəfə doktoru, Gəncə, Azərbaycan
[2]Azərbaycan Respublikası Elm və Təhsil Nazirliyi Genetik Ehtiyatlar İnstitutu, Bakı, Azərbaycan
[3]Naxçıvan Dövlət Universitetinin Bioresurslar İnstitutu, biologiya elmləri doktoru, Naxçıvan, Azərbaycan
[4]Naxçıvan Dövlət Universitetinin Bioresurslar İnstitutu, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: mirzyevaa@bk.ru
Daxil oldu: 20 Fevral 2026; Qəbul edildi: 6 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

Given the diverse topography and climatic variability of Azerbaijan, newly developed silkworm (Bombyx mori) breeds must possess high adaptive potential to ensure stable expression of their genetic traits under fluctuating environmental conditions (Tzenov & Grekov, 2008; Vasileva et al., 2005). Although this presents a significant challenge, it is a solvable one. In recent years, research in Azerbaijan has focused on elucidating the genetic mechanisms underlying silkworm responses to

environmental variation (Abbasov, 2000). For the first time in sericulture, the scientific and theoretical foundations of adaptive selection have been established, along with practical approaches for their implementation. These advances have enabled the development of silkworm breeds with enhanced resilience to diverse environmental stressors (Abdullayeva, 2025).

From both economic and agricultural perspectives, the properties of the cocoon shell—the principal structural component of the cocoon—are highly variable and of critical importance. One of the most effective strategies for increasing natural silk and cocoon production is the development of high-yielding, technologically superior silkworm breeds and hybrids through selective breeding (Huo et al., 2023; Zhang et al., 2021). The technological characteristics of cocoons are primarily determined by the biological traits of the silkworm strain, the level of agro-zootechnical management during rearing, and the methods applied in primary cocoon processing, as well as other associated factors (Kumar & Prasad, 2018; Ganie et al., 2020). At the same time, it should be noted that although considerable research has been devoted to improving the biological productivity of silkworm breeds, significantly less attention has been paid to the stability and consistency of technological indicators under suboptimal and seasonally variable environmental conditions (Umarov, 2005). In particular, there is a lack of comprehensive studies addressing how adaptive selection influences key technological traits such as filament length, reelability, raw silk yield, and metric number across different rearing seasons (Hemmatabadi et al., 2016).

This gap is especially important for regions with unstable climatic conditions, where environmental stress factors such as high temperature, low humidity, and fluctuations in mulberry leaf quality can significantly affect both the productivity and technological performance of silkworms. Traditional breeding approaches, which are typically conducted under optimal conditions, may not adequately reflect the real production environment, thereby limiting the practical applicability of newly developed breeds (Tzenov & Grekov, 2008). In this context, the present study contributes to the field by applying adaptive selection under pessimal (suboptimal) rearing conditions and by evaluating the technological characteristics of silkworm genotypes across multiple seasons. The scientific novelty of this research lies in the integrated assessment of technological indicators under environmental stress conditions, as well as in identifying genotypes that combine high productivity with enhanced adaptability and stability (Hemmatabadi R., 2016; Huo, 2023).

Therefore, the aim of this study is to evaluate the technological characteristics of newly developed silkworm genotypes and to determine their suitability for seasonal rearing under unfavorable environmental conditions, with particular emphasis on their performance stability and industrial relevance (Chen et al., 2022; Zhang et al., 2021). Mulberry silkworm breeds and hybrids produce a single commercial product—raw silk. However, numerous economically important quantitative traits influence both the quantity and quality of this product. The yield of raw silk is largely determined by cocoon productivity, larval viability, cocoon shell ratio (silk content), reelability of dry cocoons, and overall raw silk recovery. In addition, resistance to infectious diseases and efficient feed utilization (feed conversion efficiency) play a significant role. In contrast, the quality of raw silk is mainly affected by the total and continuous filament length reeled from a single cocoon, filament fineness (metric number), and uniformity. Genetic improvement of these traits ultimately leads to enhanced productivity and quality of raw silk (Abbasov, 2001; Navruzov, 2020; Alimova, 2023).

Methods

The aim of this selection program was to evaluate silkworm families and individual cocoons by genotype, using cocoon shell ratio (silk content of live cocoons) as the primary selection criterion, and to develop two new mulberry silkworm (*Bombyx mori*) breeds. These breeds were intended to surpass the best regionally adapted strains in key technological and productivity indicators.

Synthetic populations Hesa 2/1 × Khayal and Mziuri 5 × Mayak 6 were used as the initial breeding material. From each population, 40–45 egg batches (nests) were incubated, and the 50 best-performing and surviving families were selected for rearing. During rearing, particular attention was given to larval development, viability, and the morphological characteristics of both larvae and cocoons. Families and individuals that did not meet the selection criteria were eliminated. Selection was initiated in the second generation and continued through the eighth generation.

Experimental Material

Adaptive selection methodology was applied using the newly developed hybrids Hesa 2/1 × Khayal (Atlas 1) and Mziuri 5 × Mayak 6 (Atlas 2). The study aimed to develop strains suitable for rearing under different seasonal conditions.

Experimental Design and Conditions

Experiments were conducted over a three-year period under unfavorable environmental conditions, including elevated temperatures, low relative humidity, and suboptimal feeding regimes. Rearing trials were performed during three seasonal cycles: spring, summer, and autumn. Such experimental conditions were intentionally selected to simulate real production environments and to evaluate the adaptability and stability of technological traits under environmental stress. Throughout the first three years, larvae of both sexes were reared under standard agro-zootechnical conditions without replication. Beginning in the fourth year, experimental groups were established, consisting of three replicates of 250–300 larvae per sex. These groups were reared under suboptimal (pessimal) conditions until the completion of larval development. To simulate stress conditions, the temperature was maintained at 27–28°C and relative humidity below 55–60% throughout the feeding period. Feeding frequency was six times per day in the fourth year and four times per day in the fifth year.

During the fourth and fifth years, continuous visual assessment of larval morphology was carried out during selection rearing. Individuals and entire families that deviated from the established phenotypic standard, as well as those exhibiting low survival rates due to disease or other factors, were systematically excluded. Technological parameters were determined using samples of cocoons obtained from each replicate. For each experimental variant, 25 male and 25 female cocoons were subjected to standard processing procedures, including stifling (thermal treatment), drying, and reeling. Based on these procedures, key technological indicators were evaluated.

Data Collection and Evaluation

Quantitative data obtained during the study was analyzed using appropriate statistical methods to assess variation and performance across the experimental groups. Mean values were calculated based on repeated observations over three years.

The following technological indicators of cocoons were evaluated:
cocoon weight (mg),
cocoon shell weight (mg),
shell ratio (%),
raw silk yield (%),
cocoon reelability (%),
filament length (m),
metric number (m/g).

Calculation of Technological Indicators

The calculation of cocoon technological indicators was performed using the following formulas.

a) Shell ratio;

$$I = \frac{X + S + K}{N} \cdot 100;$$

where: X – the weight of pure silk; S – the weight of silk floss; K – the weight of the shell; N – the weight of sample cocoon.

b) Silk yield, in%:

$$I = \frac{1}{N} \cdot 100;$$

where: I – the weight of pure silk, N – the weight of sample cocoon;
c) Cocoon reelability:

$$A = \frac{1}{I + S + K} \cdot 100;$$

where: I – the weight of pure silk, grams; S – the weight of silk floss, grams; K – the weight of shell - grams.
d) The length of silk filament, meter;

$$U = \frac{U}{B};$$

where: U – general reeled silk filament; B – number of cocoons.
e) Metric number of silk filament

$$M_n = \frac{U}{X};$$

where: U – general reeled silk, meter; X – the weight of pure silk, gram.

Results and discussion

As a result of experiments conducted across three different seasons (spring, summer, and autumn) using the adaptive selection method, two new silkworm breeds—Atlas 1 and Atlas 2—were developed. These breeds are technologically advanced and meet modern sericultural requirements. The hybrids of silkworm such asHesa 2/1 × Khayal (Atlas 1) and Mizuri 5 × Mayak 6 (Atlas 2) were used as the breeding material for this study. Based on the average results obtained over a three-year experimental period, the findings demonstrated that, despite fluctuations in environmental conditions, the technological indicators remained consistent, and the quality of silk was preserved. Consequently, these results formed the basis for the assessment of the silkworms' technological traits. Given that the primary objective is to obtain abundant and high-quality raw silk, the silkworm breeds under evaluation must exhibit high adaptability. Just as biological indicators reflect agricultural productivity, technological indicators should correspond to industrial demands and are, in this context, of even greater significance. As presented in the table, the selected genotypes demonstrated robust performance, with high results observed under seasonal feeding conditions. Of particular industrial relevance is the weight of a single dry cocoon, as it determines the ratio between wet and

dry cocoon yields. In this regard, the wet cocoon weight was notably high in both breeds: in Atlas 1, the average weight reached 870 mg, while in Atlas 2, it was 793 mg.

Table 1
Average technological indicators of the newly developed silkworm breeds

№		Dry cocoon		Raw silk		Cocoon reeling, %	Silk filament	
	Name of the breeds	Average mass, mg	Shell ratio, %	Average mass, mg	Shell ratio, %		Total length, m	Metric number, m/g
1	Atlas 1	870	49,95	384	44,2	88,8	1693	4422
2	Atlas 2	793	49,05	349	44,3	90,3	1309	3700

The cocoon shell ratio of dry cocoons showed very similar values in both breeds, amounting to 49.95% in Atlas 1 and 49.05% in Atlas 2. This parameter is a key technological indicator, as it directly influences the potential yield of raw silk. Cocoon reelability represents another critical technological characteristic, as it has a direct impact on processing efficiency and overall productivity. Poor reelability leads to interruptions during reeling and, consequently, reduced production efficiency. In the present study, both breeds exhibited high reelability, reaching 88.8% in Atlas 1 and 90.3% in Atlas 2. Among the technological traits, filament thickness and length are of particular importance for silk processing and textile applications. Deviations from standard filament thickness, either excessively coarse or overly fine—are generally undesirable for weaving, although such variations may be inherent to specific breeds.

The average filament length reeled from a single cocoon was 1,693 m in Atlas 1 and 1,309 m in Atlas 2. Atlas 1 produced a longer and finer filament, whereas Atlas 2 yielded a comparatively thicker filament. This suggests that Atlas 1 is more suitable for applications requiring finer and longer fibers, while Atlas 2 may offer advantages in terms of filament strength and durability. Overall, both breeds fall within the acceptable limits for key technological indicators. In terms of raw silk quality, Atlas 2 may be considered superior due to its lower metric number and shorter filament length, which indicate a thicker filament better suited for certain industrial applications.

The metric number of the reeled silk, defined as the ratio of filament length (m) to weight (g), also differed between the breeds. It reached 4,422 m/g in Atlas 1 and 3,700 m/g in Atlas 2, indicating that Atlas 1 produces finer and longer filaments, as higher values correspond to greater fineness. Raw silk yield, a principal indicator of technological efficiency in sericulture, was nearly identical in both breeds, amounting to 44.2% in Atlas 1 and 44.3% in Atlas 2. Overall, the results indicate that Atlas 1 is characterized by a fine and long filament, satisfactory reelability, and high raw silk yield. In contrast, Atlas 2 exhibits a thicker filament of moderate length, superior reelability, and similarly high productivity. Importantly, according to all evaluated technological parameters, the silk produced by these newly developed breeds meets the advanced standards established for modern silkworm breeds and hybrids in the Republic of Azerbaijan.

Conclusion

The results of the selection experiment indicate that maintaining breeding material under suboptimal (pessimal) feeding conditions is more effective for evaluating and enhancing genotype performance. Under these conditions, both newly developed breeds, Atlas 1 and Atlas 2, exhibited consistent patterns across key technological indicators. Specifically, selection led to a stable improvement in technological traits rather than merely altering them, ultimately contributing to increased raw silk productivity. Moreover, the genetic gains in technological traits were more pronounced under

suboptimal feeding conditions. Despite exposure to unfavorable environmental factors, both breeds maintained high cocoon shell ratio (silk content), demonstrating their stability and resilience. These findings suggest that, over the course of three years and across three seasonal cycles (spring, summer, and autumn), the studied lines have become well-established breeds characterized by high ecological adaptability and strong technological performance.

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The Taxonomic Analysis of the *Astragalus* Species (*Fabaceae* Lind l.) in Flora of Azerbaijan

Dashgin Ganbarov[1*], Yegane Aslanova[2], Safura Babayeva[3], Habib Huseynov[3], Namiq Abbasov[3]

Abstract. *The article provides information on the taxonomic composition of species belonging to the genus* Astragalus *(Fabaceae Lindl.) in the flora of Azerbaijan. Based on literature data and our own field studies, for the first time, 143 species belonging to the subgenera* Astragalus *and* Cercidothrix *have been identified in the flora of Azerbaijan. The conducted research has shown that the subgenus* Astragalus *is represented by 80 species within 27 sections, while the subgenus* Cercidothrix *comprises 63 species within 12 sections. Additionally, for the first time, the distribution of species belonging to the subgenera* Astragalus *and* Cercidothrix *across sections has been investigated. It has been determined that the sections* Incani *– 17 species,* Onobrychoidei *– 10,* Malacothrix *– 10,* Caprini *– 9,* Rhacophorus *– 8,* Dissitiflori *– 6,* Ornithopodium *– 5,* Hypoglottidei *– 5,* Adiaspastus *– 5,* Hololeuce *– 4,* Alopecuroidei *– 4, and* Aegacantha *– 4 species, while several other sections are represented by 1–3 species. Based on the analysis of botanical-geographical regions, it has been established that 84 species of the genus* Astragalus *are distributed in the Nakhchivan Autonomous Republic, 56 species in the Greater Caucasus, 45 in the Lesser Caucasus, 31 in the Lankaran region, and 15 in the Kura-Araz lowland. Furthermore, characteristic species for each botanical-geographical region are also indicated in the article.*

Keywords: *taxonomic analysis, subgenus, Astragalus, Cercidothrix, characteristic species*

[1]Nakhchivan State University, Doctor of Sciences in Biology, Nakhchivan, Azerbaijan
[2]Ganja State University, PhD in Biology, Ganja, Azerbaijan
[3]Nakhchivan State University, PhD in Biology, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: dasqinqenberov@ndu.edu
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Azərbaycan florasında Astragalus növlərinin (Fabaceae Lindl.) taksonomik təhlili

Daşqın Qənbərov[1*], Yeganə Aslanova[2], Safura Babayeva[3], Habib Hüseynov[3], Namiq Abbasov[3]

Xülasə. *Məqalədə Azərbaycan florasında Astragalus (Fabaceae Lindl.) cinsinə aid növlərin taksonomik tərkibi haqqında məlumat verilmişdir. Ədəbiyyat məlumatlarına və şəxsi çöl tədqiqatlarına əsasən tərəfimizdən ilk dəfə olaraq Azərbaycan florasında Astragalus və Cercidothrix yarımcinslərinə aid 143 növünə rast gəlinir. Aparılan tədqiqatlar zamanı məlum olmuşdur ki, Astragalus yarımcinsi 27 seksiya üzrə 80, Cercidothrix yarımcinsi isə 12 seksiya üzrə 63 növlə təmsil olunur.*

Həmçinin, ilk dəfə olaraq tərəfimizdən Astragalus və Cercidothrix yarımcinslərinə daxil olan növlərin seksiyalar üzrə paylanması tədqiq olunmuşdur. Məlum olmuşdur ki, Incani – *17,* Onobrychoidei – *10,* Malacothrix – *10,* Caprini – *9,* Rhacophorus – *8,* Dissitiflori – *6,* Ornithopodium – *5,* Hypoglottidei – *5,* Adiaspastus – *5,* Hololeuce – *4,* Alopecuroidei – *4,* Aegacantha – *4, bir sıra seksiyalar isə 1–3 növlə təmsil olunur. Botaniki-coğrafi rayonların təhlili əsasında müəyyən edilmişdir ki, Astragalus cinsinə aid növlərin 84-ü Naxçıvan Muxtar Respublikası ərazisində, 56-ı Böyük Qafqaz, 45-i Kiçik Qafqaz, 31-i Lənkəran bölgəsində, 15-i isə Kür-Araz ovalığında yayılmışdır. Həmçinin, məqalədə hər bir botaniki-coğrafi rayon üçün xarakterik növlər qeyd olunmuşdur.*

Açar sözlər: *taksonomik təhlil, yarımcins, Astragalus, Cercidothrix, xarakterik növlər*

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[1]Naxçıvan Dövlət Universiteti, biologiya üzrə elmlər doktoru, Naxçıvan, Azərbaycan
[2]Gəncə Dövlət Universiteti, biologiya üzrə fəlsəfə doktoru, Gəncə, Azərbaycan
[3]Naxçıvan Dövlət Universiteti, biologiya üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: dasqinkenberov@ndu.edu
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Introduction

The genus *Astragalus* is the largest among the genera of flowering plants. According to expert estimates by D. Podlech & Sh. Zarre (2013), *Astragalus* includes at least 2850 species (500 in America; 2350 in the Old World). Within the boundaries of the former USSR, there are 988 species of this genus (Cherepanov, 1995) and 235 in the Caucasus (Sytin, 2009). The data are somewhat outdated, as new species are described every year, and new localities are noted in different regions. The flora of Azerbaijan differs from the flora regions of the world with its rich vegetation and variety, and also attracts the attention of world researchers. The regional distribution, taxonomic composition, bioecological characteristics, etc. of higher plants in the flora of the republic such information can be found in the works of our research scientists. However, the data on the number of *Astragalus* species and their distribution in different regions of Azerbaijan are completely insufficient, with the exception of the territory of Nakhchivan MR (Ganbarov & Ibrahimov, 2015 a; 2015 b; Ganbarov et al., 2015; Ganbarov et al., 2023). A relatively new, but very brief summary of the flora of A.M. Askerov (2016) regarding the genus *Astragalus* does not contain new data.

Methods

The data on the most significant floristic reports for the flora of Azerbaijan are critically summarized: Flora of the Caucasus and Analysis of the flora of the Caucasus (Grossheim, 1936, 1952), Flora of USSR (1946), Flora of Azerbaijan (1954), Vegetation of Azerbaijan (Prilipko, 1970), *Astragalus* of Eastern Europe and the Caucasus (Sytin, 2009). These data are supplemented by new ones, which were established by the authors of the article over the past ten years of floristic research. Field studies were carried out based on the route-stationary method. During expeditions covering various physical-geographical and floristic regions of Azerbaijan, species of the *Astragalus* genus were discovered in natural conditions, samples were collected, and geographical coordinates of each locality were recorded using GPS. Based on the collected materials, the spreading area of each species within Azerbaijan was determined and systematized by regions.

Plant samples were processed according to standard herbarium methods: samples were dried, mounted on herbarium sheets, and stored in appropriate scientific funds. These materials were used as the main basis for subsequent comparative and taxonomic analyses.

Species identification was carried out based on a complex approach - by integrating morphological and molecular-genetic methods. During morphological analysis, the external structure of vegetative and generative organs of plants were studied in detail. Leaf, stem, and root structures were measured, and diagnostic features of flowers and seeds were determined. The results obtained were compared with existing taxonomic keys, classical floristic works, and herbarium funds of the Institute of Botany.

For each species, the region where it occurs within Azerbaijan was established. Thus, the analysis of the regularities of representatives of the genus *Astragalus*, which was first considered by A.A.Grosgeim in 1936, has been reperformed on the basis of updated data. During the research, phenological observations were made and the taxonomic composition was compiled by section, taking into account the areas where the studied species are distributed (Novruzova et al., 2024). All data obtained as a result of the research were systematized, processed using comparative and analytical methods, and summarized based on modern floristic-taxonomic principles.

Results and Discussion

Based on literature data and field studies, 143 species belonging to two subgenera of the *Astragalus* genus of the *Fabaceae* family are distributed in the flora of Azerbaijan. Below the taxonomic composition of those species by section is given (Ganbarov, 2021; Ganbarov et al., 2024). List of sections, subsections, species of the genus *Astragalus* L. (*Fabaceae*) in Azerbaijan. Below are the sections in bold with a number (section numbering is continuous throughout the list); further, for each section, numbered views are given with the indication of the authors (the numbering of views is continuous throughout the list); the most common synonyms are given in parentheses with an indication of the authors); If chromosome numbers are established for species, they are given after the species name (Ganbarov et al., 2023).

Genus: *Astragalus* L. 1753, Sp. Pl.: 24, 755, id. 1754, Gen. Pl. ed. 5: 335.

Lectotypus: *A. christianus* L. (Rydberg, 1905, in Bull. Torrey Bot. Club 32)

1. Subgen. *Astragalus*

Sect. 1. *Astragalus* *(A. sect. Christiani* DC*, A. sect. Christiana* Bunge*, A. sect. Christianopsis* Gontsch**.)** 1. *A. caraganae* Hohen. (*A. nachitschevanicus* Rzazade) 2n = 16.

Sect. 2. ***Galegiformes* DC:** 2. *A. galegiformis* L. 2n = 16.

Sect. 3. ***Komaroviella* Gontsch.:** 3. *A. alpinus* L. 2n = 16, 32;

Sect. 4. *Oroboidei* A. Gray (sect. *Orobella* Gontsch.): 4. *A. brachytropis* (DC.) C.A. Mey. (*A. norvegkus* Grauer var. *brachytropis* (Steven) Hashimov) 2n = 16, 24.

Sect. 5. *Hypoglottidei* DC. (sect. *Euhypoglottis* Bunge): 5. *A. cicer.*L. 2n = 32, 48, 64; 6. *A. oreades* C.A. Mey.; 7. *A. saganlugensis* Trautv.; 8. *A. supinus* Bunge; 9. *A. klopotovskii* Sosn. (=*A vavilovii* Fedorov et Tamamsch.).

Sect. 6. *Glycyphyllos* Bunge: 10. *A. fraxinifollius* DC; 11. *A. glycyphylloides* DC. 2n = 16; 12. *A. glycyphyllos* L. 2n = 16

Sect. 7. *Erionotus* Bunge: 13. *A dasyanthus* Pall.

Sect. 8. *Caprini* DC. (sect. *Myobroma* Bunge): 14. *A, fabaceus* Bieb. (*A. tumidus* Bieb. nom. illeg. поп Willd. 1794); 15. *A. angustiflorus* C Koch 2n= 16; 16. *A. schemachensis* Karjagin; 17. *A.*

bakuensis Bunge; 18. *A. pinetorum* Boiss. (*A. declinatus* Willd., *A. declinatus* Willd. var. *subglaber* Freyn et Boram., *A. declinatus* Willd. var. *suprahirsutus* Freyn, *A. talyschensis* Bunge) 2n = 16; 19; *A. polyphyllus* Bunge; 20. *A. aegobromus* Boiss. et Hohen. (*A. torrentum* Bunge) 2n = 16; 21.*A. kirpicznikovii* Grossh. 2n=16; 22. *A. pseudoutriger* Grossh. 2n=16.

Sect. 9. *Macrosemium* Bunge: 23. *A. paradoxus* Bunge.

Sect. 10. *Alopecuroidei* DC. (sect *Alopecias* Bunge): 24. *A. megalotropis* C.A. Mey.; 25. *A. macrocephalus* Willd. (*A. finitimus* Bunge, *A. sphaerocephalus* Manden., *A. oloricus* Manden., *A. sphaerocephalus* Manden., *A. johannis* Rzazade) 2n = 16; 26. *A. echinops* Boiss. (*A. regelii* Trautv.); -27. *A. alopecurus* Pall. (*A. maximus* Willd.) 2n = 16;

Sect. 11. ***Melacothrix* Bunge:** 28. *A. podocarpus* C.A. Mey.; 29. A. *macrostachys* DC; 30.*A. eugenii* Grossh 31. *A. elegans* Bunge; 32. *A. kabristanicus* Grossh.; 33. *A. mollis* M. Bieb. *(A. eriocarpus* M. Bieb., *A longibracteatus* Sommier et Levier) 2n = 16; 34. *A. takhtadzhjanii* Grossh. 2n= 16; 35. *A. rzaevii* Grossh.; 36. *A. neoalbanicus* Podlech (*A. albanicus* Grossh.); 37. *A. aznabjurtkus* Grossh.; 38. *A. macrourus* Fisch. et C.A. Mey. (*A. schachbusensis* Rzazade).

Sect. 12. ***Grammocalyx* Bunge:** 39. *A. lineatus* Lara. (*A. sphaerocalyx* Ledeb., *A. grammocalyx* Boiss, et Hohen., *A. gezeldarensis* Grossh.) 2n = 48.

Sect. 13. *Anthylloidei* DC. (sect. *Halicacabus* Bunge): 40. *A. mesites* Boiss. et Buhse; 41. *A. karakuschensis* Gontsch.

Sect. 14. *Macrophyllium* Boiss.: 42. *A. cephalotes* Banks et Sol. (*A. sommieri* Freyn); 43. *A. karjaginii* (Boriss.) Boriss. (*A. barba-caprina* Al. Fed., Fed. et Rzazade); 44. *A. oleaefolius* DC. (*A. lagowskii* Trautv., *A. oleaefolius* subvar. *alexandrii* Sirj.).

Sect. 15. *Aegacantha* Bunge (sect. *Acanthophace* Bunge**):** 45. *A. sahendi* Fisch.; 46. *A. beckerianus* Trautv.; 47. *A. sangesuricus* Boriss.; 48. *A. euoplus* Trautv.

Sect 16. *Adiaspastus* Bunge (sect. *Tragacantha* W.D.J. Koch, nomen illegit., non sect. *Tragacantha* DC. 1825): 49. *A. aureus* Willd. (*A. pseudotragacantha* Pall., *A. sivasicus* Bunge, *A. macropodius* Fisch.; *A. flavirubens* Al. Fed., Fed. et Rzazade) 2n = 16, 32; 50. *A. caucasicus* Pall.; 51. *A. caspicus* M. Bieb. (*A. theodorovianus* Al. Fed. et Rzazade); 52. *A. vedicus* Takht. (*A. karabaghensis* subsp. *vedicus* (Takht.) Takht., *A. polyanthus* subsp. *vedicus* (Takht.) Zarre); 53. *A. karabaghensis* Bunge (*A. araxinus* Lipsky).

Sect. 17. *Rhacophorus* Bunge (sect. *Stenonychium* Bunge; sect. *Microthrix* Sirj.): 54. *A. denudatus* Steven (*A. marschallianus* Fisch.) 2n = 32; 55. *A. meyeri* Boiss.; 56. *A. compactus* Lam. (*A. strictifolius* Boiss., *A. strictifolius* var. *kutepovii* Sirj., *A. insidiosus* (Boriss.) Boriss.); 57. *A. microcephalus* Willd. (*A. pycnophyllus* Steven, *A. andreji* Al. Fed., Fed. et Rzazade, *A. terekensis* Al. Fed., Fed. et Rzazade, *A. carthlicus* Al. Fed., Fed. et Rzazade, *A. gudrathii* Al. Fed., Fed. et Rzazade, *A. atenicus* Ivanisch.). 58. *A. stenonychioides* Podlech, 59. *A. alexeenkoana* Podlech. 60. *A. jucundus* Al. Theod., Fed. & Rzazade; 61. *A. alexeenkoana* Podlech

Sect. 18. *Hymenostegis* Bunge: 62. *A. lagopoides* Lara. (*A. lagurus* Willd.); 63. *A. uraniolimneus* Boiss. 64. *A. persicus* Fisch. & C.A. Mey. ex Bunge

Sect. 19. *Campylanthus* Bunge (sect. *Tricholobus* Bunge): 65. *A. hohenackeri* Boiss.

Sect. 20. *Ankylotus* Bunge: 66. *A. commixtus* Bunge; 67. *A. camptaceras* Bunge 2n = 16.

Sect. 21. *Annotates* DC. (sect. *Harpilobus* Bunge); 68. *A. campylorhynchus* Fisch. et C.A. Mey.; 69. *A. crenatus* Schult. (*A. corrugatus* Bertol.); 70. *A reticulatus* M.Bieb.;

Sect. 22. *Cycloglottis* Bunge: 71. *A. contortuplicatus* L. 2n = 16.

Sect. 23. *Aulacolobus* Bunge: 72. *A. guttatus* Banks et Sol.; 73. *A. onobrychis* L. (*A. striatellus* Pall. ex M. Bieb.) 2n =16.

Sect. 24. *Bucerates* Bunge: 74. *A. hamosus* L**.**

Sect. 25. ***Oxyglottis* Bunge:** 75. *A. oxyglottis* M. Bieb. 2n = 16; 76. *A. ammophilus* Kar. & Kir. 77. *A.psiloglottis* Steven 2n=16

Sect. 26. ***Sesamei* DC:** 78. *A. asterias* Hohen. (*A. cruciatus* Link.) 2n = 16; 79. *A. tribuloides* Delile 2n = 14, 16;

Sect. 27. *Magalocystis* Bunge. 80. *A. szovitsii* Fisch. & C.A. Mey.

2. Subgen. *Cercidothrix* Bunge 1868, Mem. Acad. Sci. Petersb. (Sci. Phys. Math.), ser. 7, 11, 16: 94. Lectotypus: A. incanus L.

Sect. 28. *Uliginosi* Gray (*Euodmus*** Bunge): 81. *A. falcatus* Lam. 2n = 16; 82. *A. odoratus* Lam. 2n = 14, 16.

Sect. 29. *Incani* DC. (sect *Proselius* Bunge**):** 83. *A. monspessulanus* L. 2n = 16; 84. *A. somcheticus* K. Koch (*A. polygala* Pall.) 2n = 16; 85. *A. buschiorum* Galushko *(A. alexandrii* Charadze) 2n = 16; 86. *A. achundovii* Grossh.; 87. *A. orduhadensis* Grossh.; 88. *A. montis-aquillae* Grossh.; 89. *A. sanguinolentus* M. Bieb.; 90. *A. brachycarpus* M. Bieb. 2n = 16; 91. *A. robustus* Bunge (*A. subrobustus* Boriss.) 2n = 32; 92. *A. cuscutae* Bunge; 93. *A. longicuspis* Bunge; 94. *A. prilipkoanus* Grossh.; 95.*A. refractus* CA. Mey.; 96. *A. kazbeki* Charadze 2n = 16; 97. *A. rostratus* C.A. Mey.; 98. *A. zangelanus* Grossh.; 99. *A. latifollus* Lam. (*A. candolleanus* Boiss., *A. choicus* Bunge, *A. heteromorphus* Boriss., *A. fedorovii* Takht., *A. sukaczevii* Derv. et Jelenevsky) 2n = 16;

Sect. 30. *Euhypoglottis* Bunge: 100. *A. brachypetalus* Traurv. 101. *A. kubensis* Grossh.

Sect. 31. *Onobrychoidei* DC. (sect. *Onohychium* Bunge**):** 102. *A. onobrychis* L. (*A. hybridus* S.G. Gmelin, *A. borysthenicus* Klok., *A. troitzkii* Grossh., *A. pseudoonobrychis* auct. non Andrz.; non Grossh.) 2n = 16, 32, 64; 103. *A. bungeanus* Boiss. (*A. perembelicns* Grossh., *A. borissovae* Grossh., *A. kukurttavicus* Prokh.) 2n = 16, 56; 104. *A. sevangensis* Gross. (*A. leonidae* Manden.) 2n = 32; 105. *A. arguricus* Bunge (*A. kozlovskyi* Grossh.) 2n = 16, 32; 106. *A. cancellatus* Bunge (*A. pseudocancellatus* Grossh., *A. darriensis* Grossh., *A. perrarus* Boriss.) 2n = 16, 32; 107. *A. kadshorensis* Bunge; 108. *A. captiosus* Boriss. (*A. interpositus* Boriss., *A. ketzkhovelii* Kharadze, *A. klukhoricus* Sosn.) 2n = 16+2B, 16; 109. *A. shagalensis* Grossh.; 110. *A. goktschaicus* Grossh. (*A. onobrychis* subsp. *goktschaicus* Ponert; *A. atrocarpus* Chamberlain et Mathews; *A. kosmaljanicus* Rzazade) 2n = 40; 111. *A. conspicuus* Boriss. (*A. aduncus* auct. non Willd.) 2n = 16; 112. *A. hajastanus* Grossh. 2n = 16. 33

Sect. 32. *Hololeuce* Bunge: 113. *A. dzhebrailicus* Grossh.; 114. *A. zuvanlicus* Grossh. 115. *A. incertus* Ledeb. 2n= 16, 32; 116. *A. onobrychioides* M. Bieb. (*A. cephalotes* Pall. *A. canescens* DC, *A. subcaulescens* auct. non Royle, non Ledeb., *A. ruprechtii* Bunge, *A. owerinii* Bunge) 2n = 32; 117. *A. elbrusensis* Boiss.118. *A. schuschensis***.** 119. *A. gjunaicus* Grossh.

Sect. 33. ***Ornithopodium* Bunge** 120. *A. ornithopodioides* Lam. (*A. stevenianus* var. *multijugus* Trautv., *A. multijugus* (Trautv.) Grossh., *A. bylowae* Jelenevsky); *A.glochideus* Borris.; 121. *A.*

stevenianus DC. (*A. junceus* Ledeb., *A. davuricus* K. Koch, *A. conrathii* Freyn, *A. virgeus* Boriss., *A. stevenianus* var. *stevenianus* Chamberlain) 2n = 32; 122. *A. kochianus* Sosn.; 123. *A. lunatus* Pall.; 124. *A. shelkovnikovii* Grossh.

Sect. 34. *Synochreati* DC: 125. *A. resupinatus* Bieb. (*A. fragrans* Willd.) 126. *A. levieri* Sommier. et Levier.

Sect. 35. *Dissitiflori* DC. (sect. *Vesicarii* DC, sect. *Xiphidium* Bunge, sect. *Cystodes* Bunge); 127. *A. viridis* Bunge; 128. *A. cornutus* Pall., 129. *A. commits* Pall. (*A. vimineus* Pall.; *A. odessanus* Besser, *A. lussiae* Rzazade) 2n = 48; 130. *A. xiphidium* Bunge (*A. husseinovii* Rzazade, *A. marasiensis* Rzazade); 131. *A. haesitabundus* Lipsky; 132. *A. argyroides* Beck. ex Stapf (*A. novus* Grossh.); 133. *A. sachokianus* Grossh. 134. *A.subulatus* Bieb.

Sect. 36. *Cystium* Bunge (sect. *Paracystium* Gontsch.): 135. *A. biebersteinii* Bunge;

Sect. 37. *Trachycercis* Bunge: 136. *A. humilis* M. Bieb. (*A. humilis* var. *subsericea* Trautv. *A. kikodzeanus* Sosn., *A. theodorii* Grossh., *A. humilis* subsp. *theodori* (Grossh.) Hashimov, *A. vanensis* Sosn., *A. teberdensis* Grossh.) 2n = 64; 137. *A. badamliensis* Chalilov 138. *A. erivanensis* Bornm. et Woronov (*A. pseudohumiiis* Grossh.; *A. chalilovii* Grossh.) 139. *A. barnassari* Grossh.

Sect. 38. *Laguropsis* Bunge: 140. *A. calycinus* M. Bieb. 2n = 16.

Sect. 39. *Ammodendron* Bunge 141. *A. karakugensis* Bunge 2n = 16; 142. *A. hyrcanus* Pall. 2n = 16, 143. *A. igniarius* Pop

Taking into account, the distribution ratio of species belonging to the *Astragalus* genus is given in the table below (Table 1.)

Table 1
Distribution of species in the subgenera Astragalus and Cercidothrix

	Subgenera *Astragalus*	
S/№	**Section**	**Number of species**
1	*Astragalus*	1
2	*Galegiformes*	1
3	*Komaroviella*	1
4	*Oroboidei*	1
5	*Hypoglottidei*	5
6	*Glycyphyllos*	3
7	*Erionotus*	1
8	*Caprini*	9
9	*Macrosemium*	1
10	*Alopecuroidei*	4
11	*Melacothrix*	11
12	*Grammocalyx*	1
13	*Anthylloidei*	2
14	*Macrophyllium*	3
15	*Aegacantha*	4
16	*Adiaspastus*	5
17	*Rhacophorus*	8
18	*Hymenostegis*	3
19	*Campylanthus*	1

20	*Ankylotus*	2
21	*Annulares*	3
22	*Cycloglottis*	1
23	*Aulacolobus*	2
24	*Bucerates*	1
25	*Oxyglottis*	3
26	*Sesamei*	2
27	*Magalocystis*	1
Total	**27**	**80**
	Subgenera *Cercidothrix*	
1	*Uliginosi*	2
2	*İncani*	17
3	*Euhypoglottis*	2
4	*Onobrychoiei*	11
5	*Hololeuce*	7
6	*Ornithopodium*	5
7	*Synochreati*	2
8	*Dissitiflori*	8
9	*Cystium*	1
10	*Trachycercis*	4
11	*Laguropsis*	1
12	*Ammodendron*	3
Total	**12**	**63**

As can be seen from the table, subgenus *Astragalus* is dominantly represented by 80 species in 27 sections. In this section, *Malacothrix* 10, *Caprini* 9, *Rhacophorus* 8, *Hypoglottidei* and *Adiaspastus* 5, *Alopecuroidei* and *Aegacantha* are represented by 4 species, *Glycyphyllos*, *Hymenostegis*, *Annulares*, *Oxyglottis* sections by 3 each, and the rest by 1-2 species. The subgenus *Cercidothrix* includes 63 species in 12 sections, and in this section *Incani* 17, *Onobrychoidei* 10, *Dissitiflori* 6, *Ornithopodium* 5, *Hololeuce* 4, and the remaining sections are represented by 1-3 species. In the flora of Azerbaijan, it is important to study the distribution of species belonging to the genus Astragalus in botanical-geographical regions. Ganbarov D.Ş. in his doctoral dissertation on "Preservation of phytocenological, eco-biological characteristics and gene pool of *Astracantha* and *Astragalus* (*Fabaceae* Lindl.) species distributed in Nakhchivan Autonomous Republic", since the studied species were comprehensively studied, we will continue our further research with other botanical-geographical ones. we consider it expedient to conduct by regions. Therefore, when determining the distribution of the researched species in the flora of the republic, 4 different botanical-geographical regions were taken and a comparative analysis of those regions was studied. The table below shows the distribution of species belonging to the genus *Astragalus* by botanical-geographical regions (Table 2.).

Table 2
The Comparative analysis of species belonging to Astragalus genus by botanical-geographical regions

№	Species	Greater Caucasus	Lesser Caucasus	Kura-Araz Lowland	Lankaran (Talish region)	Nakhchivan AR
1.	*A. caraganae*				+	+
2.	*A. galegiformis*	+		+		
3.	*A. alpinus*	+				+
4.	*A. brachytropis*	+				
5.	*A cicer*	+	+			+
6.	*A. oreades*	+				
7.	*A. saganlugensis*		+			+
8.	*A. supinus*	+				
9.	*A. fraxinifolius*					+
10.	*A. glycyphyttoides*	+	+		+	+
11.	*A. glycyphyllos*	+				+
12.	*A dasyanthus*					+
13.	*A, fabaceus*	+		+		+
14.	*A. angustiflorus*					+
15.	*A. bakuensis*	+				
16.	*A. pinetorum*				+	+
17.	*A. declinatus*	+	+			
18.	*A. polyphyllus*	+				+
19.	*A. aegobromus*					+
20.	*A. torrentum*					+
21.	*A. kirpicznikovii*		+			
22.	*A.pseudoutriger*	+		+	+	
23.	*A. paradoxus*					+
24.	*A. megalotropis*				+	
25.	*A. macrocephalus*	+				+
26.	*A. echinops*					+
27.	*A. alopecurus*		+		+	
28.	*A. podocarpus*				+	
29.	*A. macrostachys*		+			+
30.	*A. eugenii*	+				
31.	*A. elegans*				+	
32.	*A. kabristanicus*	+				
33.	*A. mollis*		+	+		+
34.	*A. takhtadzhjanii*					+
35.	*A. rzaevii*		+			
36.	*A. neoalbanicus*	+				
37.	*A. aznabjurticus*					+
38.	*A. macrourus*				+	+
39.	*A. lineatus*					+
40.	*A. mesites*		+			+
41.	*A. karakuschensis*					+
42.	*A. karjaginii*					+
43.	*A. oleifolius*					+
44.	*A. sahendi*				+	
45.	*A. beckerianus*	+				
46.	*A. zangesuricus*		+			

| | | |

98.	*A. sukaczevii*		+			
99.	*A. brachypetalus*		+			
100.	*A. kubensis*	+				
101.	*A. bungeanus*	+	+			+
102.	*A. sevangensis*		+			+
103.	*A. arguricus*		+			+
104.	*A. canceltatus*		+			+
105.	*A.kadshorensis*		+			
106.	*A. captiosus*	+				
107.	*A. shagalensis*		+			
108.	*A. goktschaicus*		+		+	+
109.	*A. conspicuus*					+
110.	*A. hajastanus*		+			+
111.	*A. dzhebrailicus*		+			
112.	*A. zuvanticu*				+	
113.	*A. incertus*	+	+			+
114.	*A. onobtychioides*	+				+
115.	*A. elbrusensis*				+	
116.	*A. schuschensis*		+			
117.	*A. gjunaicus*		+			
118.	*A. ornithopodioides*				+	
119.	*A.glochideus*				+	
120.	*A. stevenianus*	+		+		+
121.	*A. kochianus*		+	+		+
122.	*A. lunatus*	+				+
123.	*A. shelkovnikovii*					+
124.	*A.resupinatus*		+		+	+
125.	*A levieri*	+				
126.	*A. viridis*					+
127.	*A. cornutus*					
128.	*A. xiphidium*	+			+	
129.	*A. haesitabundus*	+				
130.	*A. argyroides*					+
131.	*A. sachokianus*	+				
132.	*A.subulatus*		+		+	
133.	*A. biebersteinii*	+				
134.	*A. humilis*	+				
135.	*A. badamliensis*					+
136.	*A. erivanensis*					+
137.	*A. chalilovii*					+
138.	*A.barnassari*				+	
139.	*A. calycinus*		+			+
140.	A.*schernchensis*	+				
141.	*A. hyrcanus*	+				
142.	*A. igniarius*	+		+		
143.	*A. cephalotes*					+
	Total:	**56**	**45**	**15**	**31**	**84**

As seen from Table 2, there are species that are considered characteristic of only one botanical-geographical region, and there are also species that are found in other botanical-geographical regions (Figure 1.).

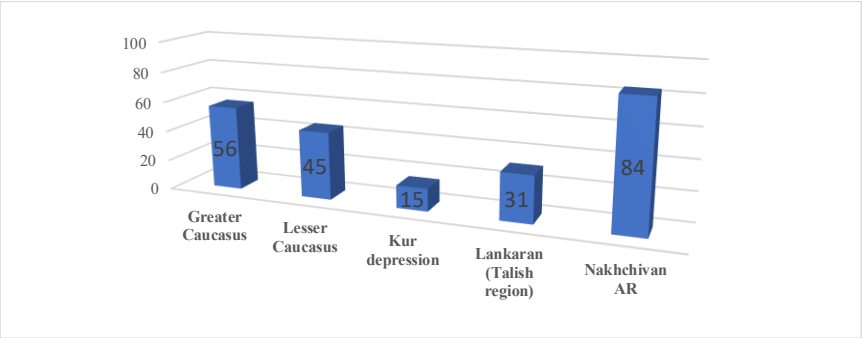

Figure 1
The percentage distribution of species belonging to the genus Astragalus across the regions of Azerbaijan

There are 84 species of the genus *Astragalus* in the flora of the Nakhchivan Autonomous Republic, which makes up 58.74% of the total flora. In the mentioned region, *A. cephalotes, A. paradoxus, A. aznabjurticus, A. karakuschensis, A. shelkovnikovii* A. *viridis*, *A. argyroides, A. longicuspis, A. latifolius* etc. such species are found only in this area. It was found out from the conducted researches that 56 species of the genus *Astragalus* are distributed in the flora of the Greater Caucasus and make up 39.16% of the total flora. In the mentioned region, *A. brachytropis, A. supinus, A. bakuensis, A. eugenii, A. neoalbanicus, A. monspessulamus, A. buschiorum, A. cuscutae, A. kubensis, A. haesitabundus, A. sachokianus, A. humilis , A. hyrcanus*, etc. such species are found only in this area. 31 species of the genus *Astragalus* are distributed in Lankaran (Talysh region), which makes up 21.67% of the total flora. For this region, only A. *megalotropis, A. podocarpus, A. elegans, A. sahendi, A. hohenackeri, A. refractus, A. zuvanticu, A. elbrusensis, A. barnassari*, etc. types are found. It should also be noted that the flora of this region is more similar to the flora of Nakhchivan MR.

15 species of the genus *Astragalus* are found in the flora of the Kura basin and are represented by 10.48% of the studied flora. Only *A. reticulatus* is considered a characteristic species for this area. Another 14 species are also found in the regions mentioned above. In the flora of the Lesser Caucasus, 45 species of the genus *Astragalus* are found, which is 31.46% of the studied flora *A. kirpicznikovii, A. rzaevii, A. brachypetalus, A. bungeanus* and *A. sukaczevii* are considered characteristic species for this area. According to the literature sources, *Astragalus ordubadensis* has been reported from the Ordubad district of the Nakhchivan Autonomous Republic and the Lesser Caucasus region. However, no photographs of this species have been found in any of the published literature (floras). This species was recorded by us for the first time on 13 July 2024 in the phrygana vegetation of the village of Khoshbulag in the Dashkasan district. Herbarium specimens of the species were collected and deposited in the Herbarium collection of the Department of Biology at Nakhchivan State University (Figure 2.).

Figure 2
Astragalus ordubadensis

Thus, the above-mentioned does not fully reflect the distribution of species belonging to the genus *Astragalus* in botanical-geographical regions. In our future studies, it is considered appropriate to conduct complex studies, taking into account the distribution of the studied species in different regions.

Conclusion

1. Furthermore, for the first time, we have investigated the sectional distribution of species belonging to the subgenera *Astragalus* and *Cercidothrix*. The study revealed that these subgenera are represented by various sections, with the highest species counts found in *Incani* (17), *Onobrychoidei* (10), and *Malacothrix* (10), followed by *Caprini* (9), *Rhacophorus* (8), *Dissitiflori* (6), *Ornithopodium* (5), *Hypoglottidei* (5), *Adiaspastus* (5), *Hololeuce* (4), *Alopecuroidei* (4), and *Aegacantha* (4), while several other sections are represented by 1–3 species each.
2. According to the results of the conducted research, *Fabaceae* Lindl in the flora of Azerbaijan. 143 species belonging to two subgenera of the genus *Astragalus* are distributed. It was found that subgenus *Astragalus* is represented by 80 species in 27 sections, and subgenus Cercidothrix is represented by 63 species in 12 sections.
3. Based on the analysis of botanical-geographical regions, it was determined that 84 species of the genus *Astragalus* are found in Nakhchivan MR, 56 species in the Greater Caucasus, 45 in the Lesser Caucasus, 31 in Lankaran (Talish region), and 15 in the Kura plain. Also, characteristic species found in each botanical-geographic region were studied.

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Modern Therapeutic Approaches and Concepts for the Treatment of Trichophytosis in Calves

Vusala Sardarly[1*], Ramil Mammadov[2], Konul Dunyamaliyeva[3], Sevinj Novruzova[3], Nargiz Huseynova[3]

Abstract. *The aim of the present study was isolating and identifying the causative agents of ringworm in cattle and to comparatively evaluate the therapeutic efficacy of the LTF-201 "Arm" vaccine in the treatment of calf trichophytosis when used in combination with the immunomodulator Mixoferon and the topical etiotropic agent Akamiksan. The study was carried out at a private farm owned by Veli Kuliev, located in the Karaarkh settlement of the Samukh district, as well as at the regional veterinary diagnostic laboratory. During clinical examination of 150 calves, signs of dermatophytosis were detected in 30 animals (20%). To confirm the diagnosis, skin scrapings were collected from the border between affected and healthy skin areas of suspected animals. The samples were subjected to direct microscopic examination and inoculated onto mycobiotic culture media followed by incubation at 25 °C. Mycological examination resulted in the isolation and identification of fungi belonging to the genus* Trichophyton *from diseased calves. To assess treatment efficacy, 30 affected calves were divided into two groups of 15 animals each. Calves in the first group received the LTF-201 "Arm" vaccine intramuscularly at a dose of 2 mL, the immunomodulatory Mixoferon at a dose of 2000 IU/kg, and topical application of Akamiksan to the affected skin areas. Animals in the second group received the LTF-201 "Arm" vaccine at a dose of 2 mL and topical treatment with Akamiksan without administration of Mixoferon. It was established that calves affected by trichophytosis developed secondary immunodeficiency predominantly involving the humoral component of the immune system. During the active stage of the disease, interferon levels decreased by more than 2.5-fold, accompanied by a reduction in the bactericidal and lysozyme activity of blood serum compared with clinically healthy animals. The use of the LTF-201 "Arm" vaccine in combination with Mixoferon provided more rapid restoration of nonspecific resistance parameters, accelerated reparative processes in the skin and regrowth of hair, and significantly reduced the time to clinical recovery compared with the treatment regimen without immunomodulatory support.*

Keywords: *dermatophytosis, LTF-201 "Arm" vaccine, Mixoferon, Akamiksan, blood sampling, bactericidal and lysozyme activity of serum, immunomodulator*

[1]Azerbaijan State Agrarian University, PhD of Biology, Ganja, Azerbaijan
[2]Azerbaijan State Agrarian University, PhD of Agrarian Sciences, Ganja, Azerbaijan
[3]Azerbaijan State Agrarian University, Ganja, Azerbaijan
[*]Corresponding author. E-mail: vusalasardar@hotmail.com
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Buzovlarda trixofitiyanın müalicəsinə dair müasir terapevtik yanaşmalar və konsepsiyalar

Vüsalə Sərdarlı[1*], Ramil Məmmədov[2], Könul Dünyamalıyeva[3], Sevinc Novruzova[3], Nərgiz Hüseynova[3]

Xülasə. *Bu tədqiqatın məqsədi iri buynuzlu heyvanlarda dəmronun törədicilərinin ayrılması və identifikasiyası, həmçinin buzovlarda trixofitiyanın müalicəsində LTF-201 "Arm" vaksininin Mixoferon immunomodulyatoru və Akamiksan yerli etiotrop preparatı ilə birlikdə tətbiqinin terapevtik effektivliyinin müqayisəli şəkildə qiymətləndirilməsi olmuşdur. Tədqiqat Azərbaycan Respublikasının Samux rayonunun Qaraarx qəsəbəsində yerləşən Vəli Quliyevə məxsus özəl fermer təsərrüfatında və Regional Baytarlıq Diaqnostika laboratoriyasında aparılmışdır. 150 baş buzovun klinik müayinəsi zamanı 30 heyvanda (20,0 %) dermatofitozlara xas kliniki əlamətlər aşkar edilmişdir. Diaqnozun təsdiqi məqsədilə şübhəli heyvanların zədələnmiş və sağlam dəri sahələrinin sərhədindən dəri qaşıntıları götürülmüşdür. Alınmış nümunələr birbaşa mikroskopik müayinədən keçirilmiş və mikobiotik qida mühitlərinə əkilərək 25–28 °C temperaturda inkubasiya olunmuşdur. Aparılmış mikoloji tədqiqatlar nəticəsində xəstə buzovlardan Trichophyton cinsinə aid dermatofit göbələkləri ayrılmış və identifikasiya edilmişdir. Müalicənin effektivliyini qiymətləndirmək üçün 30 xəstə buzov hər birində 15 baş olmaqla iki qrupa bölünmüşdür. Birinci qrupun heyvanlarına LTF-201 "Arm" vaksini 2 ml dozada əzələdaxili yeridilmiş, Mixoferon 2000 BV/kq dozada tətbiq edilmiş və zədələnmiş dəri sahələrinə Akamiksan preparatı çəkilmişdir. İkinci qrupun heyvanlarına isə LTF-201 "Arm" vaksini və yalnız Akamiksan preparatı tətbiq olunmuş, Mixoferon istifadə edilməmişdir. Müəyyən edilmişdir ki, trixofitiya ilə xəstə buzovlarda əsasən humoral immun sistemini əhatə edən ikincili immunçatışmazlıq inkişaf edir. Xəstəliyin aktiv mərhələsində interferonun səviyyəsi 2,5 dəfədən çox azalır ki, bu da klinik cəhətdən sağlam heyvanlarla müqayisədə qan zərdabının bakterisid və lizozim aktivliyinin aşağı düşməsi ilə müşayiət olunur. LTF-201 "Arm" vaksininin Mixoferon ilə birlikdə tətbiqi qeyri-spesifik rezistentlik göstəricilərinin daha sürətli bərpasını, dəridə reparativ proseslərin və tük örtüyünün regenerasiyasının sürətlənməsini, eləcə də immunomodulyatorsuz müalicə sxemi ilə müqayisədə klinik sağalma müddətinin statistik cəhətdən əhəmiyyətli dərəcədə qısalmasını təmin etmişdir.*

Açar sözlər: *dermatofitoz, LTF-201 "Arm" vaksini, Miksoferon, Akamiksan, qan nümunəsinin götürülməsi, qan zərdabının bakterisid və lizosim aktivliyi, immunomodulyator*

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[1]Azərbaycan Dövlət Aqrar Universiteti, biologiya üzrə fəlsəfə doktoru, Gəncə, Azərbaycan
[2]Azərbaycan Dövlət Aqrar Universiteti, Aqrar elmlər üzrə fəlsəfə doktoru, Gəncə, Azərbaycan
[3]Azərbaycan Dövlət Aqrar Universiteti, Gəncə, Azərbaycan
[*]Məsul müəllif. E-poçt: vusalasardar@hotmail.com
Daxil oldu: 9 Fevral 2026; Qəbul edildi: 21 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

At present, dermatophytes in animals are widely distributed and occupy a leading position in the structure of skin and skin appendage diseases (Achterman, 2012, Martinez-Rossi 2017). This is due to the ability of dermatophytes to persist in the external environment for a long time without losing their pathogenic properties. The absence or untimely implementation of diagnostic, therapeutic, and preventive measures contributes to the further spread of the disease (Al-Ani 2002, Bredahl 2000, Chermette 2008, Khosravi 2003).

In livestock complexes and private farms, dermatophytes often occur in the form of enzootics, which is associated with a high level of pathogen carriage among animals (Khmylyov 2019, Moretti, 2013). These diseases are also characterized by pronounced seasonality: the highest number of outbreaks is recorded in the winter–spring period, which correlates with a decrease in the immunoreactivity of the animal organism (Mukhamadiev, et al. 2023, Sargison et al. 2002, Shchelkunova et al., 2012). In recent years, a steady increase has been observed in the number of dermatophyte strains resistant to antifungal drugs used in veterinary practice. The use of existing specific therapeutic and preventive measures does not ensure complete eradication of dermatophytes in farm animals, which necessitates the search for new treatment approaches. One of the promising directions is the development of economically affordable, safe, and highly effective drugs with pronounced antimitotic activity against dermatophytes (Mitra et al., 1998, Kozlova, 2022, Karibaeva, 2010). Despite the availability of a wide range of medicinal agents used for dermatophytes, the selection of an optimal therapeutic regimen remains a complex task. Therefore, the improvement of treatment strategies for trichophytosis in calves remains highly relevant both scientifically and practically.

Objective. The aim of this study was the isolation and identification of the causative agents of ringworm in cattle, as well as a comparative evaluation of the therapeutic efficacy of the LTF-201 “Arm” vaccine in combination with the immunomodulatory Myxoferron and the topical dexiotropic drug Akamiksan, compared with the use of the LTF-201 “Arm” vaccine combined with the topical agent Akamiksan without immunomodulatory support. Additionally, the study aimed to analyze the dynamics of clinical condition in animals during treatment and to determine the duration of reparative recovery in the post-therapeutic period. This allowed the identification of optimal approaches for therapy correction and the development of recommendations to reduce treatment duration and improve overall therapeutic efficacy.

Figure 1
Diseased animal

Sample collection: Skin scrapings were collected from the periphery of the affected areas after treatment with 70% ethyl alcohol. The collected material was delivered to the regional laboratory for mycological examination.

Mycological examination: All samples were examined using direct microscopy for the presence of fungal elements. Skin scales and hair samples were treated with a 10% potassium hydroxide (KOH) solution for 10 minutes, after which microscopic examination was performed to detect fungal hyphae and spores.

Sabouraud medium was used as a nutrient medium for mycological examination for fungal cultivation, as well as a special diagnostic medium, Fung Assay. The Fung Assay medium contains a

pH indicator and additives that inhibit bacteria and saprophytic fungi. When dermatophytes grow on this medium, a change in pH occurs, and the medium turns red.

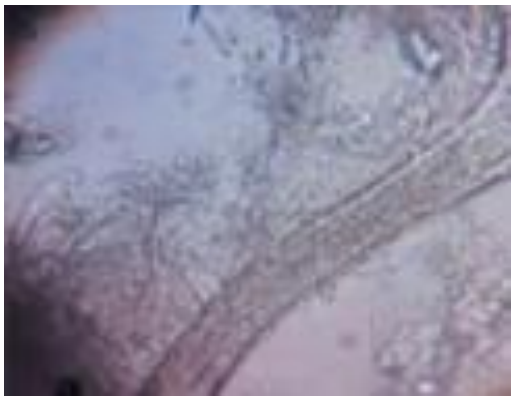
A  B

Figure 2

A. Fungal hyphae and spores in clinical samples observed during microscopic examination. B. Inoculation of clinical material was performed using Fung Assay medium

The samples were cultured on nutrient media for several weeks at a temperature of 25°C. From the developed colonies, a fragment of mycelium was collected using a bacteriological loop, transferred into a drop of 50% aqueous glycerol solution, covered with a coverslip, and examined under a microscope. Fluorescent (luminescent) diagnostics were also performed using a Wood's lamp (ultraviolet radiation with a wavelength of 365 nm) in a darkened room. Before examination, the affected skin areas were cleaned of dirt, crusts, and residues of medicinal products. During the examination, the presence of characteristic fluorescence of hair and skin scales was assessed. In the examined calves, no bright emerald-green fluorescence characteristic of infection caused by fungi of the genus *Microspore* was observed. The absence of specific fluorescence suggested that the causative agent of the disease belonged to the genus *Trichophyte*, which was later confirmed by mycological examination results.

For the purpose of performing a biological test and final identification of the causative agent, experimental infection of rabbits was carried out. The study was conducted in accordance with the requirements of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes, adopted on March 18, 1986, with adherence to the principles of humane treatment of laboratory animals. In rabbits experimentally infected with fungi of the genus *Trichophyte*, characteristic skin lesions developed at the inoculation sites three weeks after infection. These lesions were manifested by inflammation, skin scaling, and focal alopecia. Upon repeated mycological examination of material obtained from the affected skin areas, cultures of fungi of the genus *Trichophyte* were again isolated on nutrient media, confirming the etiological role of these pathogens in the development of the disease.

In addition, during the experiment, clinical and immunological parameters of the animals were assessed before and after therapy. The following materials and methods were used:

Hematological studies: determination of erythrocyte count, hemoglobin level, and leukocyte count.

Immunological studies: assessment of the bactericidal and lysozyme activity of blood serum.

Blood sampling was carried out in the morning before feeding the animals. To obtain serum, a portion of the blood was incubated in a thermostat at a temperature of 37–38°C for 20–30 minutes. After clot formation, the serum was transferred to a refrigerator and stored at 0–15°C until analysis. Using standard methods, the counts of erythrocytes, hemoglobin concentration, leukocytes, and the

leukocyte differential formula in the blood of animals were determined. The number of erythrocytes and leukocytes per 1 μL of blood was measured using an automated "Coulter Counter" (LH module) manufactured by Coultronics France (France), according to the manufacturer's instructions. A 20 μL sample was diluted (1:10 for erythrocyte counting and 1:10 for leukocyte counting) with filtered 0.9% NaCl solution. During leukocyte counting, erythrocytes were lysed by adding 0.1 mL of a 10% saponin solution.

Hemoglobin in the blood was determined using a special photometer manufactured by Lundberg (Sweden). A 20 μL sample was diluted with 3.5 mL of 0.1 N sodium bicarbonate solution, placed in a cuvette, and measured photometrically. The instrument readings were compared with a special calibration chart. For the determination of the leukocyte formula, blood smears were prepared on degreased glass slides. The air-dried smears were immediately stained using the Pappenheim method, which combines preliminary staining with May–Grünwald stain followed by counterstaining with Romansky–Giemsa stain. The leukocyte differential count was determined according to the Filippchenko method by counting 200 cells using a special laboratory 11-key counter (SL–1). The blood formed elements were expressed in the following units: erythrocytes in millions/μL, leukocytes in thousands/μL, hemoglobin in g%, and the relative proportions of individual leukocyte types in percentages.

The bactericidal activity of blood serum (BABS) was determined by the method of O.V. Smirnova and T.A. Kuzmina (1966), modified by I.A. Saladyn (1983). In sterile test tubes, 2.5 mL of meat-peptone broth was added, followed by 0.55 mL of the tested serum; in the control samples, the same volume of broth was added instead of serum. Then, 0.025 mL of a 24-hour broth culture of *Escherichia coli* was added to all tubes. The mixture was thoroughly mixed, after which 1.5 mL samples were taken for nephelometric determination of optical density. The remaining samples were incubated in a thermostat at 39°C for 2 hours and 25 minutes, after which optical density was again measured using an FEC-56M photo-colorimeter with a green filter. BABS was calculated using the standard formula.

The lysozyme activity of blood serum was determined by the method of O.V. Bukharin (1971). In test tubes, 1 mL of the tested serum, 1 mL of 0.5% sodium chloride solution, and 2 mL of a suspension of a 24-hour agar culture of *Micrococcus lysodeikticus* in 0.5% NaCl solution were added. The control sample was prepared in the same way, replacing the serum with physiological saline. Optical density was measured before and after incubation in a thermostat at 37°C for 2.5 hours using a green filter. To study the therapeutic efficacy of the proposed treatment regimens, the affected calves were divided into two groups of 15 animals each.

The animals were treated according to the following scheme:
Group I: LTF-201 "Arm" vaccine administered intramuscularly at a dose of 2 mL; Myxoferron administered intramuscularly at a dose of 2000 IU/kg; and topical application of Akamiksan to the affected areas.

Group II: LTF-201 "Arm" vaccine administered intramuscularly at a dose of 2 mL; topical application of Akamiksan to the affected areas; Myxoferron was not used.

The LTF-201 "Arm" vaccine is prepared from an attenuated culture of the fungus *Trichophyton verrucosum* TV-201 VGNKI, which is subjected to lyophilization using a protective sucrose–gelatin medium (10% sucrose, 2% gelatin) in a 1:1 ratio. Before use, the vaccine is reconstituted at a ratio of 1 cm^3 of diluent per dose of vaccine. The diluent may be a special diluent for dry vaccines against animal dermatophytes, an isotonic sodium chloride solution, water for injection, or cooled boiled water. For this purpose, the diluent is drawn into a sterile syringe and, under aseptic conditions, injected into the vaccine vial. Upon shaking, the vaccine is rapidly resuspended, forming a

homogeneous suspension. The hair coat at the injection site is first clipped, and the skin is disinfected with 70% ethyl alcohol or another disinfectant solution. During vaccine administration, the rules of asepsis and antisepsis are strictly observed.

Akamiksan. Each 1 g contains sulfur – 100 mg, zinc oxide – 100 mg, and the following excipients: salicylic acid – 100 mg, birch tar – 50 mg, sanitary lysol of grade "A" or creolin – 10 mg, purified or gum turpentine – 20 mg, metacid – 5 mg, vaseline – 400 mg, anhydrous lanolin – 170 mg, and purified water – 75 mg (17).

Myxoferron. The main active substance of the drug is human recombinant interferon alpha-2b, the production of which is based on recombinant DNA technology.

The general clinical examination of the animals included inspection of the skin and visible mucous membranes, measurement of body temperature, palpation of lymph nodes, and auscultation of the respiratory and cardiovascular systems. The animals were observed over a 14-day period.

Results of the study. The study was conducted in two stages. At the first stage, the immunobiological status of the animals was assessed prior to the initiation of therapy.

When determining hematological parameters in diseased calves, a significant increase in the number of blood leukocytes was revealed, while the levels of erythrocytes and hemoglobin remained within the normal range. The data are presented in Table 1. Thus, in diseased calves, the erythrocyte count ranged from 5.93 ± 0.62 to 6.80 ± 0.63 T/L, compared with 7.7 ± 0.28 T/L in healthy animals ($P < 0.05$). Hemoglobin levels ranged from 110.4 ± 6.75 to 111.5 ± 6.1 q/L, compared with 116.0 ± 2.3 q/L in healthy animals ($P < 0.05$). The leukocyte count ranged from 12.0 ± 1.70 to 10.9 ± 0.43 q/L, compared with 9.5 ± 0.4 q/L in healthy animals ($P < 0.05$). Changes in the bactericidal and lysozyme activity of blood serum were also observed. In diseased calves, bactericidal activity ranged from 31.8 ± 0.9 to 32.2 ± 1.02%, compared with 46.5 ± 1.02% in healthy animals ($P < 0.05$). Lysozyme activity in diseased calves was 29.1 ± 2.8 to 30.0 ± 0.8%, compared with 34.5 ± 0.70% in healthy animals ($P < 0.05$).

At the second stage of the study, the affected calves were treated according to the following regimen: animals of the first group received an intramuscular injection of the "LTF-201 Arm" vaccine into the neck region at a dose of 2 mL (2 cm^3). The affected skin areas were treated with Akamiksan ointment without prior removal of crusts or clipping of the hair coat: twice daily during the first 2–3 days, then once daily thereafter. Before application, the Akamiksan container was thoroughly shaken, and for greater efficacy the preparation was gently rubbed into the skin using a swab. In addition, Myxoferron was administered intramuscularly at a dose of 2000 IU/kg.

Calves of the second group received an intramuscular injection of the "LTF-201 Arm" vaccine into the neck region at a dose of 2 cm^3. The affected skin areas were treated with Akamiksan ointment without prior removal of crusts or clipping of the hair coat: twice daily during the first 2–3 days, then once daily thereafter. Myxoferron was not used. Therapeutic revaccination in both groups was carried out after 14 days. To analyze the dynamics of immunobiological parameters in the animals, blood samples were collected on the 7th day after therapeutic revaccination.

When determining hematological parameters in calves of both treated groups, normalization of erythrocyte and hemoglobin levels was observed, as well as a decrease in leukocyte counts. In calves of the first group, the erythrocyte count was 7.14 ± 0.62 – 7.2 ± 0.25 T/L ($P < 0.05$), hemoglobin level was 110.4 ± 0.75 – 111.5 ± 2.1 q/L ($P < 0.05$), and leukocyte count was 7.9 ± 1.70 – 8.9 ± 0.43 q/L ($P < 0.05$). In calves of the second group, the erythrocyte count was 6.7 ± 0.62 – 6.80 ± 0.63 T/L (P

< 0.05), hemoglobin level was 91.0 ± 1.8 – 110.5 ± 2.6 q/L (P < 0.05), and leukocyte count was 10.0 ± 1.70 – 10.9 ± 0.43 q/L (P < 0.05).

Table 1
Hematological parameters of calves in both groups after treatment

Parameter	Group I	Group II	Normal physiological values
Erythrocytes, T/L	7,14 ± 0,62 → 7,2 ± 0,25	6,7 ± 0,62 → 6,80 ± 0,63	7,7±0,28
Hemoglobin, q/L	110,4 ± 0,75 → 111,5 ± 2,1	91,0 ± 1,8 → 110,5 ±2,6	116,0 ± 2,3
Leukocytes, q/L	7,9 ± 1,70 → 8,9 ± 0,43	10,0 ± 1,70 → 10,9 ± 0,43	9,5±0,4

The obtained data indicate that after the administered treatment, the values of erythrocytes, hemoglobin, and leukocytes in animals of both groups were within physiological norms, reflecting the positive effect of the applied therapy on the functional state of the blood and the overall health of the calves. The bactericidal and lysozyme activity indicators of blood serum in animals of the experimental groups differed significantly. In calves of the first group, serum bactericidal activity was 45.5 ± 2.02% (P < 0.05), and lysozyme activity was 34.5 ± 0.70 U/mL (P < 0.05). In calves of the second group, these parameters were lower: bactericidal activity was 32.2 ± 1.02% (P < 0.05), and lysozyme activity was 30.2 ± 1.02 U/mL (P < 0.05).

Table 2
Indicators of bactericidal and lysozyme activity of blood serum in calves of the experimental groups

Group	Bactericidal activity, %	Lysozyme activity, U/mL
First group	45,5± 2,02	34,5± 0,70
Second group	32,2 ± 1,02	30,2 ± 1,02

The conducted study revealed a significant difference in the level of nonspecific immunity between the experimental groups of calves.

The first group demonstrated a high level of bactericidal and lysozyme activity, indicating a more pronounced ability of blood serum to eliminate pathogenic microorganisms and support local immunity.

The second group showed lower values, which indicates a reduced level of nonspecific immune defense of the organism.

Thus, the data confirm that the treatment applied in the first group contributed to a more effective activation of the immune system and an increased resistance of animals to secondary infections. In calves of the first group, the overall therapeutic effect was observed as early as the 10th day after the second vaccine administration. This was manifested by thinning and gradual detachment of trichophytic crusts, as well as the appearance of new hair growth. In calves of the second group, the process of normalization and restoration of the skin and hair coat proceeded more slowly and lasted for about one month.

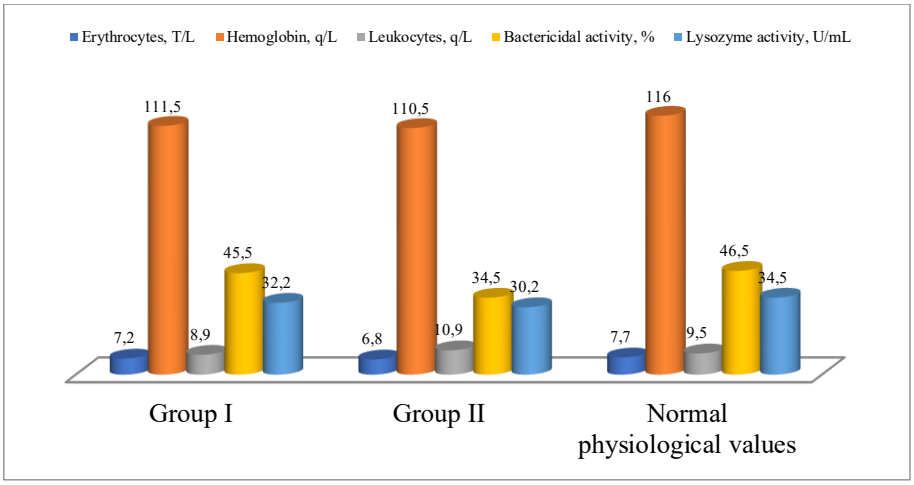


Chart 1
Blood parameters of calves in both groups after treatment

Table 3
Comparison of the Dynamics of the Therapeutic Effect in the Two Groups

Parameter	Group I	Group II
Onset of therapeutic effect	10th day after the second administration	Within one month
Clinical manifestations	Thinning and detachment of trichophytic crusts, growth of new hair	Gradual normalization of the skin and hair coat
Duration of recovery	Rapid (within several days after the onset of improvement)	Slow (up to 1 month)
Treatment efficacy	High	Moderate

Conclusion

The conducted studies demonstrated that after completion of therapy, the hematological parameters in calves of both experimental groups (erythrocyte count, hemoglobin concentration, and leukocyte count) were within physiological limits. This indicates the beneficial effect of the applied treatment regimens on the functional state of the hematopoietic system and the overall condition of the animals. At the same time, significant differences were established in the indicators of nonspecific resistance. In calves of the first group, which received the LTF-201 “Arm” vaccine in combination with the immunomodulator Myxoferron, higher levels of bactericidal and lysozyme activity of blood serum were observed compared with animals of the second group. The combined use of the LTF-201 “Arm” vaccine with Myxoferron provided a statistically significant acceleration of reparative processes in the skin and more intensive restoration of the hair coat. The immunomodulatory effect of Myxoferron promoted a faster recovery of the suppressed components of the immune system to physiological levels, which was accompanied by a reduction in the duration of the main course of treatment.

In calves of the second group, which received the vaccine in combination only with the topical dexiotropic agent, positive dynamics were also observed; however, the processes of skin regeneration and restoration of immunobiological parameters were less pronounced. Thus, the inclusion of the immunomodulatory Myxoferron in the comprehensive treatment regimen for trichophytosis in calves enhances the therapeutic efficacy of the LTF-201 “Arm” vaccine, promotes a faster restoration of immune status, and accelerates the clinical recovery of the animals.

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Study Of Technogenic Pollution Of Soil And Waters in Abandoned Fields on the North-Eastern Slope of the Lesser Caucasus

Anvar Aliyev[1*], Natig Babayev[1], Yegana Kuliyeva[2]

Abstract. *Pollution has direct and indirect effects on the nutrient and organic matter content of soils. Due to a lack of air in the waste from old copper mines with a highly acidic environment (pH 1.6–2.0), the mineralization of organic matter ceases, making direct use of the waste in agriculture impossible. Considering that this figure will increase as a result of the commissioning of new deposits in the Dashkasan region, where 51.5% of the territory is subject to pollution, it is important to pay special attention to the use of new, more modern technologies. The Z_{total} contamination level often exceeds 128, indicating extreme levels. Concentrations of heavy metals, such as lead, can exceed the maximum permissible concentration by 12.7 times. Approximately 4.3% of the surveyed areas (according to monitoring data for 2022–2025) are classified as hazardously contaminated with heavy metals, a significant portion of which are located in former industrial zones. Further downstream there are reservoirs, the infiltration waters of which reduce the pH of the water to 3–3.5. It was found that in the area affected by copper ore processing waste, significant exceedances of maximum permissible concentrations of several elements were observed. The results of environmental monitoring, including water and sediment sampling, sample preparation, and quantitative analysis of sample composition are proof of the results. The article notes that developing measures for the removal and recycling of mining and processing waste will significantly reduce the anthropogenic impact on surface waterways.*

Keywords: *technogenesis, heavy metals, pollution, anthropogenic factors, degraded landscapes, soil erosion*

[1]Institute of Geography, Ministry of Science and Education of the Republic of Azerbaijan, PhD in Geographical Sciences, Baku, Azerbaijan
[2]Institute of Geography, Ministry of Science and Education of the Republic of Azerbaijan, Baku, Azerbaijan
[*]Corresponding author. E-mail: anveraliyev840@gmail.com
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Kiçik Qafqazın şimal-şərq yamacındakı tərk edilmiş mədənlərdə torpaq və suyun texnogen çirklənməsinin öyrənilməsi

Ənvər Əliyev[1*], Natiq Babayev[1], Yeganə Quliyeva[2]

Xülasə. *Çirklənmə torpaqların qida və üzvi maddələr tərkibinə birbaşa və dolayı təsir göstərir. Köhnə mis mədənlərinin yüksək turşulu tullantılarında hava çatışmazlığı (pH 1.6–2.0) səbəbindən üzvi maddələrin minerallaşması dayanır və bu da birbaşa kənd təsərrüfatında istifadəni qeyri-mümkün*

edir. Ərazinin 51.5%-nin çirklənməyə məruz qaldığı Daşkəsən rayonunda yeni mədənlərin istismara verilməsi ilə bu göstəricinin artacağını nəzərə alsaq, yeni, daha müasir texnologiyaların istifadəsinə xüsusi diqqət yetirmək vacibdir. Ümumi çirklənmə səviyyəsi çox vaxt 128-i keçir ki, bu da həddindən artıq dəyərləri göstərir. Qurğuşun kimi ağır metalların konsentrasiyası icazə verilən maksimum konsentrasiyanı 12.7 dəfə aşa bilər. Tədqiq olunan ərazilərin təxminən 4.3%-i (2022–2025-ci illər üçün monitorinq məlumatlarına görə) ağır metallarla təhlükəli şəkildə çirklənmiş ərazilər kimi təsnif edilir ki, bunların da əhəmiyyətli bir hissəsi keçmiş sənaye zonalarında yerləşir. Aşağı axında infiltrasiya suları suyun pH-nı 3–3.5-ə endirən iriəcmli su hövzələri var. Mis filizi emalı tullantılarının təsirləndiyi ərazidə bir neçə elementin icazə verilən maksimum konsentrasiyalarından əhəmiyyətli dərəcədə artıq olduğu müşahidə edilmişdir. Ətraf mühitin monitorinqinin nəticələri, o cümlədən su və dib çöküntülərindən nümunələrin götürülməsi, nümunənin hazırlanması və nümunə tərkibinin kəmiyyət təhlili təqdim olunur. Məqalədə qeyd olunur ki, mədən və emal tullantılarının çıxarılması və təkrar emalı üçün tədbirlərin hazırlanması yerüstü su yollarına antropogen təsiri əhəmiyyətli dərəcədə azaldacaq.

Açar sözlər: *texnogenez, ağır metallar, çirklənmə, antropogen amillər, deqradasiyaya uğramış landşaftlar, torpaq eroziyası*

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[1]Azərbaycan Respublikası Elm və Təhsil Nazirliyinin Coğrafiya İnstitutu, coğrafiya elmləri üzrə fəlsəfə doktoru, Bakı, Azərbaycan

[2]Azərbaycan Respublikası Elm və Təhsil Nazirliyinin Coğrafiya İnstitutu, Bakı, Azərbaycan

[*]Məsul müəllif. E-poçt: anveraliyev840@gmail.com

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Introduction

With the development of industrial society, soils are increasingly exposed to various anthropogenic factors, which disrupt their functionality, including impacting the productivity, growth, and development of flora and fauna. In areas where mining and processing industries operate, monitoring soil changes and their overall ecological status is particularly important. The formation of anomalous areas with high heavy metal content in soils leads to a change in soil types and, consequently, to the loss of their economic potential (Aristovskaya, 1988; Akbarova, 2024). During mineral exploration, the main sources of pollution are gases and noise emitted into the atmosphere by stationary heat sources from the equipment used, various drilling rigs, and other machines and engines. Atmospheric pollution is also caused by emissions of gases and dust of varying diameters generated during blasting operations, although not continuously, but periodically (Akhundova 2025; Ali, 2026). Gas and dust emissions into the atmosphere, mineral dust pollution during mountain road construction, blasting operations and crushing of rock by machines, and the withdrawal of fertile land from cultivation in large areas where rock waste accumulates in the surrounding area are the main sources of man-made pollution resulting from wind erosion of these waste piles. Furthermore, during the mining operations, water sources here are contaminated with various minerals, particularly heavy and radioactive metals, leading to contamination of surface and groundwater (Ali, 2025; Ahmadova, 2025).

Over long periods of time, for example, during the development of deposits, beginning with geological exploration, the natural and geographic components of the area are subject to contamination in various ways (Ahmad, 2026). Furthermore, sometimes during the mining process, during their opening and subsequent exploitation, along with the enormous waste heaps, large pastures, forests, and arable lands are contaminated by rock fragments that break off from them and occupy vast areas. As a result, sometimes during the mining process, an area many times larger than

the deposits themselves is filled with their waste, known as "dumps." This also greatly increases the damage to nature (Allahverdi, 2026; Bahram, 2025; Guliyeva, 2023). The Lesser Caucasus natural region borders the Republic of Armenia to the southwest, the Republic of Georgia to the northwest, the right-bank plains of the Kura River to the northeast, and the left-bank plains of the Araz River to the southeast (Gahramanova, 2026). The natural region encompasses the physical-geographical areas of Ganja, the Karabakh Mountains, the Karabakh Volcanic Plateau, and Hakkari. It is distinguished primarily by its diverse natural conditions and wealth of natural resources. The northeastern part of the territory, along with its unique natural landscape, is also the main region of our Republic, rich in minerals, especially ore minerals (Hasanova, 2023; Ibrahimova, 2023). Man-made changes occurring in the mountainous meadow landscape of the region have dramatically altered the natural environment and completely weakened its recreational potential (Ibrahimova, 2024).

Given that this will lead to an increase in ecological stress zones, intensified man-made landslides, and the destruction of fertile land in the future, iron ore and alunite mining, as well as the reclamation of unusable landscapes, are important issues (Ikhtiyar, 2026). Samples were collected and analyzed from the control zone of the site, from the base of the waste, from a height of 20 and 70 meters above it, as well as from the soil layer at depths of 0–5 cm, 5–10 cm and 10–30 cm to study the impact of waste on the soil cover (Ismayil, 2025; Ismayilova, 2025a). Open-pit mining has caused significant structural damage to the environment. In 1985 alone, the Dashkasan mines produced $2.631 \cdot 10^6$ t of iron ore, and the processing plant produced $1.346 \cdot 10^6$ t of concentrate. $1.285 \cdot 10^6$ t of solid waste were discharged into the environment. One of the partially developed industrial regions of our republic is home to iron ore reserves, the primary raw material for the ferrous metallurgy industry the Dashkasan ore region (Ibrahimova, 2025; Ismayilova, 2025b). The Dashkasan, South Dashkasan, Demir, and Dardar ore deposits were discovered here. The ore has a rich mineral composition. Due to these properties, Dashkasan ore belongs to the Fe_3O_4 group of the most valuable iron ores. In addition to magnetite (up to 70%), the ore contains pyrite, hematite, arsenic-pyrite, titanium, copper, silver, zinc, nickel, cobalt, chromium, antimony, vanadium, molybdenum, and others (Khudaverdi, 2025; Mammadova, 2024; Mammadova, 2026).

The combined reserves of the Dashkasan iron ore deposits amount to $275.5 \cdot 10^6$ t. Until recently, only the Dashkasan deposit was being developed, with a design capacity of 26,500 t per year. In 1932, a decision was made to establish a metallurgical plant in Dashkasan by importing coal from another republic. However, in 1940, Moscow decided to build the plant in Rustavi rather than Dashkasan. In 1945, construction began on an ore processing plant in Dashkasan, which was commissioned in 1954. After iron ore is mined, the rock is purified using large quantities of water in the ore processing plants located on the plant's grounds. In addition to washing the iron ore, the iron is separated from the soil by exposure to a strong electromagnetic field (Mammadzada, 2025; Mirzezadeh, 2025). After crushing, the purified iron ore is transported via a 6 km cableway between Dashkasan and the Gushchu Bridge, and then via a 35 km railway from Alabashli to Rustavi to the final processing plant. In the 1990's, an average of $3.5\text{-}4 \cdot 10^6$ t of iron ore were mined and processed at the Dashkasan deposit. After processing this amount of rock, only $1 \cdot 10^6$ t of iron ore concentrate (with an iron content of 60%) was obtained. The remaining $2.5\text{-}3 \cdot 10^6$ t of waste remained in the region. As a result, the natural environment of these areas, which are unique mountain-meadow zones, was significantly damaged. The mining deposits that developed as a result of the development of the Dashkasan iron ore and marble, as well as the allenite reserves of Zeyli, play a significant role in the anthropogenic destruction of the mountain-meadow landscapes (Mammadova, 2024). The mountain-meadow cover in these areas, rendered unusable by the waste from the Alunit Mountain mining industry, has formed four large hills. Unused rock forms a cover here ranging from several meters to 15 meters thick. Currently, alunite waste covers an area of approximately 250 hectares.

Methods

One of the pressing and priority tasks of modern soil science is the search for and development of effective methods for cleaning contaminated soils. Therefore, detailed studies are needed to reflect and characterize the specific behavior of pollutants in soils. The anomalous content was calculated based on the criteria of metal distribution only in the upper soil layer of gray-humus horizons at a depth of 0–17 cm and the lower illuvial horizons adjacent to the parent rock at 70–80 cm, as horizons that most clearly reflect the degree of input and the nature of migration of heavy metals in the soil. The mathematical processing and calculation method for the anomaly threshold were performed according to a lognormal distribution law (Mammadova, 2025). The content of mobile forms of heavy metals in it was determined by generally accepted methods (GOST 26213-91; GOST 26207-91; GOST 26107-84; GOST 26483-85; M-MVI-80-2008). The formation of anomalous areas of heavy metals in the soil in the study area is determined by the intensity of the plant's man-made airborne industrial emissions, and the anomaly threshold value will be determined by a number of factors (Table 1). Element concentrations exceeding the anomalous threshold indicate the presence of geochemical anomalies and metal accumulation in the area. Geochemical anomaly maps were generated in the Golden Software Surfer 12 geoinformation system using the Radial Basis Functions method, which is considered one of the best methods for constructing distribution diagrams on a flat surface through experimental points. The total metal content of nitric acid soil extracts was determined using stripping voltammetry. The resulting data was used for data extraction, statistical processing, calculation of anomaly thresholds, and subsequent construction of anomalous area distribution diagrams overlaid on a terrain map using the radial basis function method.

Results

The northeastern slope of the Lesser Caucasus, along with its unique natural landscape, is also the main region of our Republic, rich in minerals, particularly ore minerals. Naturally, the development of these resources in these territories faces a serious problem: man-made pollution, which causes serious long-term damage to the environment. Typically, while some of this pollution is recoverable, much of it is irreversible. Thus, while resources such as water and air could be restored to their previous state after exploitation, restoring soil and vegetation is extremely difficult, and sometimes impossible. The main goal of this article is to assess the environmental conditions of existing man-made landscapes and develop a scientific basis for their optimization, taking into account the nature of the degraded natural landscape (Nazim, 2024).

Data analysis

It is necessary to scientifically study the difficulties of optimizing the degraded landscape in these areas, particularly the difficulties of land recycling, the impossibility of quickly restoring vegetation from a geobotanical perspective, and the sanitary and hygienic unsuitability of this area for habitation (Mirismayil, 2025). It is also necessary to consider the implementation of appropriate environmental protection measures based on modern technologies at mineral deposits that have been or will be developed in the area, both historically and currently (Nazim, 2026). Along with cleaning up the large volumes of anthropogenic waste accumulated in these areas, which include mountain forests and mountain meadows – priceless examples of nature – and using this waste in various fields (road construction, etc.), it is also possible to make a certain contribution to solving the problem of unemployment, which has already become a social disaster here. The process of returning these territories, some of the most unique corners of the republic, to their pristine natural environment is a very complex and multifaceted task (Novruz, 2025). In any case, one of the main problems is that the natural and geographical components of the territory have been exposed to various forms of pollution over a long period of time, beginning with geological exploration and mining operations (Fig. 1).

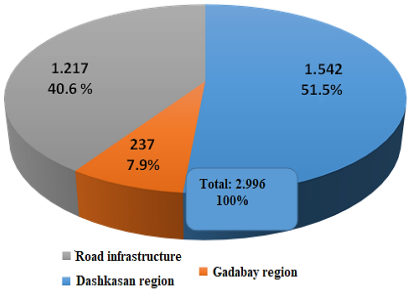
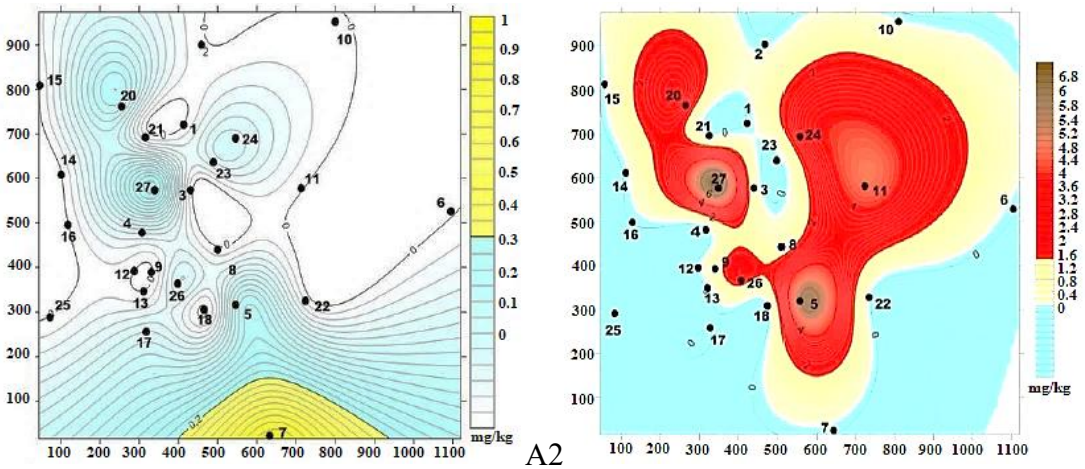


Figure 1
Percentage indicators of anthropogenic pollution in the main study areas

Anthropogenically disturbed areas by soil samples

In the study area, exceedances of the anomaly threshold were recorded in the area of sections No. 2, 3, 4, 9, 12, and 14. Low radial differentiation values, an acidic pH, and low competitive adsorption capacity characterize the migration potential of this metal within the soil profile and its presence in the lower part of the profile. In these anthropogenically disturbed areas, active aeolian processes facilitate additional mass transfer of finely dispersed fractions. In the lower part of the profile, in illuvial horizons at a depth of 70–80 cm, the anomalous threshold is several times lower than in the gray-humus horizons, at 15.8 mg/kg. Nevertheless, anomalous dispersion halos are forming in the area of profiles No. 3, 4, 12, 13, 16, and 24. The formation of these anomalous zones is likely related to active migration of humic acids down the profile (Fig. 2 A–D). Background concentrations were calculated by identifying the distribution law and further data sampling, followed by calculation of the root-mean-square logarithms of deviations for the parent rock and for the upper 0–17 cm soil layer. The background content in the parent rock is (mg/kg): Fe = 15.9; S = 0.009; Pb = 14.1; Cu = 23.1 (Fig. 3). The formation of anomalous zones with high heavy metal concentrations is largely due to various exogenous processes, along with the plant's abundant technogenic emissions. Migration, for example, results in the mass transfer of heavy metal compounds from the upper soil horizons to the illuvial horizons. Heterogeneity among the studied chalcophile elements is observed in the formation of geochemically anomalous zones. Cadmium and zinc are highly concentrated in gray-humus horizons, likely due to similarities in their electron orbital structure and bond formation. These metals partially replace divalent ions from the soil-absorbing complex. Lead and copper largely form organomineral complexes and, as a result, can migrate to a greater extent within the profile, along with humic acids, forming anomalous zones in the illuvial horizons.



A2

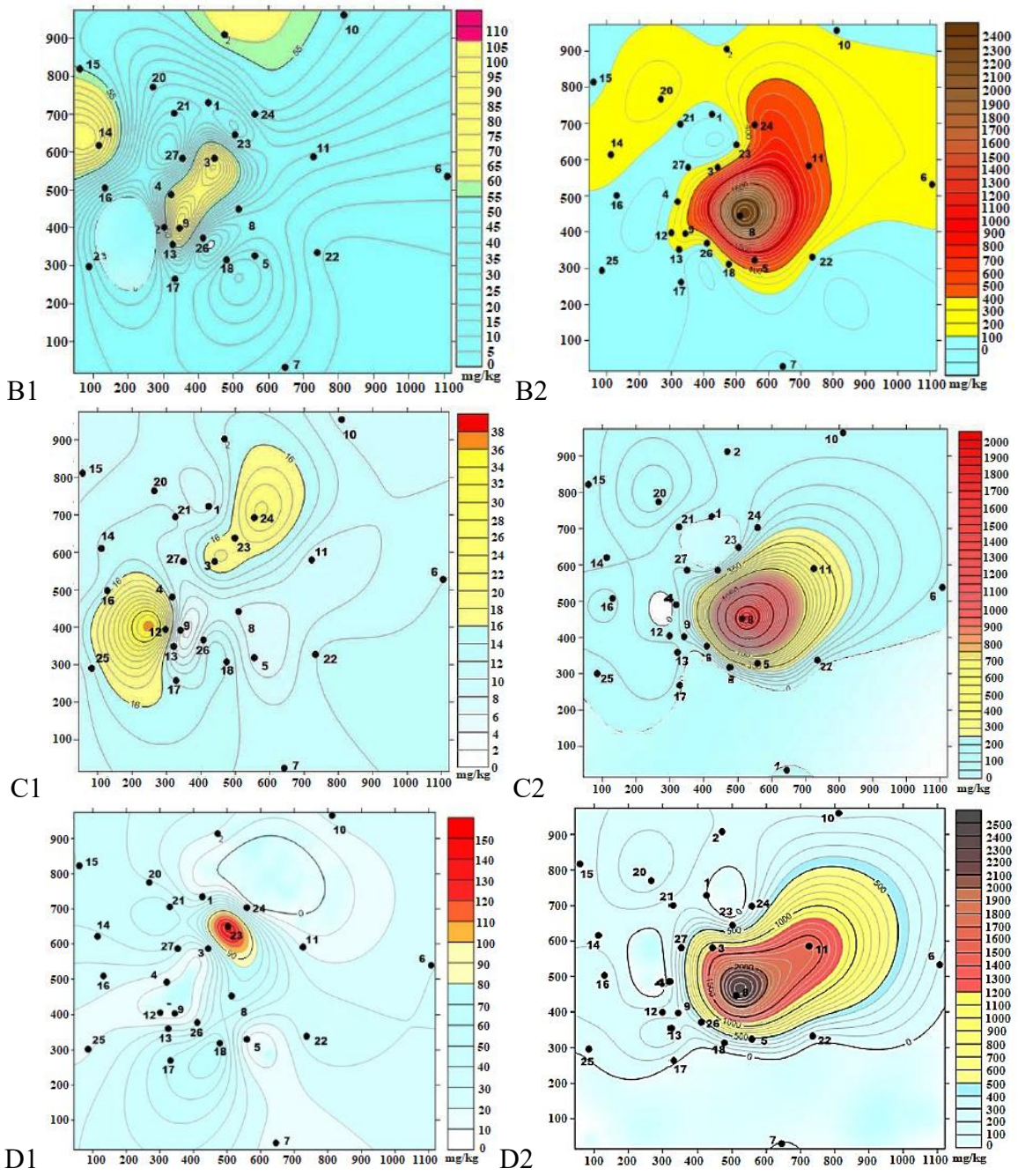


Figure 2

Geochemical anomalies: 1. illuvial horizons (70–80 cm); 2. humus-accumulative horizons (0–17 cm); S (A1–A2); Fe (B1–B2); Pb (C1–C2); Cl (D1–D2)

Small debris accumulates at the summits of terriogenic landforms formed by rock waste, while larger rocks accumulate at the base. Due to sparse vegetation, ravines with slopes of 50–60° have formed on the slopes of the waste dumps. The exploitation of the Dashkesan iron ore mines alone has rendered 1,200 ha of forest and meadow land unusable, of which 500 ha are covered by rock waste dumps. Mining waste has also chemically polluted the soil cover of mountain meadow landscapes. Analysis of soil samples taken from the waste dumps and adjacent areas shows that the content of trace elements and heavy metals in the soil is significantly higher than in natural landscapes. As a result of waste dump leaching by surface water and filtration, active chemical elements migrate and settle in the soil, contaminating it. Unused rock waste here forms a cover ranging from a few meters to 15 meters thick. The cessation of mining operations in recent years has resulted in the growth of sparse

grasses and isolated shrubs on these waste heaps. As a result of the exploitation of the Zaylik and Alunitdag mines, the 20–30 meter-high waste slopes have formed terrigenous relief features with inclinations of 45–50°, sometimes reaching 700°. Currently, alunite waste covers an area of approximately 250 ha. The physicochemical composition of the waste from the former Gadabay copper mine differs from that of other mines. This waste consists of very fine particles and is quickly washed away. Therefore, river waters in this area are seriously polluted. The pH of this water ranges from 1.6 to 2. As can be seen, the composition of the mine waters of the copper mines of the Gadabay region has an acidic reaction (Fig. 1). The total amount of mineral substances is 7-8 g/l. The SO4 content in the mine waters varies from 650 mg/l to 650 mg/l. The copper content ranges from 350 mg/l to 500 mg/l. More than 80% of the microelements are readily soluble in water. The content of mobile phosphorus here is very low - 2-3 mg/l. The mine waters are richer in nitrogen - 19-30 mg/l. The potassium content in the water is 15 mg/l. These wastes are chestnut-colored in the upper layer and dark brown in the lower layer due to excess moisture. Due to the highly acidic environment, they are deprived of air, and sometimes even leak completely. This halts the mineralization of organic matter. In other words, the plant immediately dries out, as aluminization and nitrification processes cease. At the same time, since the mobile nitrogen in these wastes combines with fixed oxides, the plant cannot assimilate them. As a result, the plant dies due to phosphorus deficiency. Therefore, direct use of these wastes in agriculture is impossible. However, various researchers have demonstrated the possibility of using them in combination with mineral fertilizers and manure (Fig. 3).

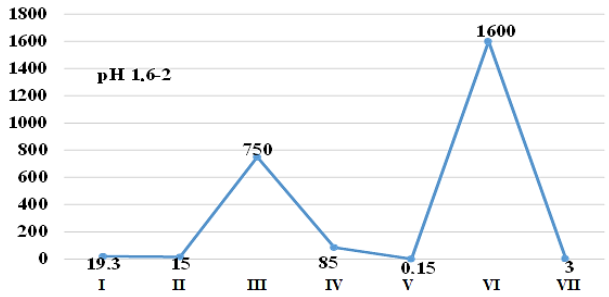


Figure 3
Agrochemical parameters of water (mg/l) in the copper mine of the Gadabay region

Note: I – Total Nitrogen; II – K; III – S; IV – Cl; V – Pb; VI – Fe; VII - P

Elemental composition of alunite landfill

The largest deposits after iron ore in the Dashkasan region are the alunite deposits in Zeylik. This deposit is considered the second largest in the world in terms of reserves, after the Fushun deposit in China. The deposit's reserves amount to $174 \cdot 10^6$ t. In addition to Al, alunite contains Na and K salts, S, and other minerals. Over time, as with other deposits in Dashkasan, open-pit mining of the alunite deposits in Zeylik led to the formation of environmentally hazardous areas, the activation of man-made landslides, and the destruction of fertile soils. As a result of the operation of the Dashkasan iron ore mines, 1,200 ha of forest and meadow lands have become unusable, of which 500 ha are covered by rock waste. Mining waste has also chemically polluted the soil cover of mountain meadow landscapes. Analysis of soil samples taken from mining waste and adjacent areas shows that the soil contains significantly higher levels of trace elements and heavy metals than in natural landscapes. As a result of waste leaching by surface water and filtration, active chemical elements migrate and settle in the soil, contaminating it. The content of these elements in soils in contact with the waste is 4–9 times higher than in natural background soils. The content of Zn, Cu, Co, Mg, B, and Hg in iron ore waste and in soils in contact with it is 4–9 times higher. As a result of the operation of the Dashkesan

iron ore mines, 1.200 ha of forest and meadow land have become unusable, of which 0,500 ha are covered by rock dumps. Mining waste has also chemically polluted the soil cover of mountain meadow landscapes. Analysis of soil samples taken from mining waste and adjacent areas shows that the content of trace elements and heavy metals in the soil is significantly higher than in natural landscapes. As a result of the washing of mined rock by surface water and filtration, active chemical elements migrate and settle in the soil, contaminating it. The concentrations of these elements in soils in contact with the waste are 4–9 times higher than in natural background soils. The concentrations of zinc, copper, cobalt, and manganese in iron ore waste and in soils in contact with it are 4–9 times higher (Table 1).

Table 1
Elemental composition (%) of samples taken at different distances from alunite landfill

Elements	**Concentration**		
	Control (150m) 0-5 cm	**5-10 cm**	**10-30 cm**
Fe	0.30944 ± 0.0002	0.31765 ± 0.00122	0.31439 ± 0.00022
Co	-	0.00479 ± 0.00059	-
Rb	0.00115 ± 0.00008	0.00111 ± 0.00007	0.00110 ± 0.00007
Sr	0.00490 ± 0.00017	0.00324 ± 0.00013	0.00334 ± 0.00013
I_2	0.00063 ± 0.00005	0.00050 ± 0.00004	0.00057 ± 0.00004
Sn	0.00269 ± 0.00011	-	-
Zr	0.00093 ± 0.00008	0.00297 ± 0.00011	0.00292 ± 0.00011
Tb	-	0.00598 ± 0.00110	-
Elements	**Concentration**		
	A1 0-5cm (Bottom of the landfill)	**A1 5-10 cm**	**A1 10-30 cm**
Fe	0.29566 ± 0.00024	0.31478 ± 0.00027	0.30752 ± 0.00023
Br	0.00026 ± 0.00004	0.00026 ± 0.00005	-
Rb	0.00129 ± 0.00008	0.00135 ± 0.00009	0.00131 ± 0.00008
Sr	0.00373 ± 0.00014	0.00378 ± 0.00015	0.00332 ± 0.00013
I_2	0.00059 ± 0.00005	0.00054 ± 0.00005	0.00052 ± 0.00004
Zr	0.00267 ± 0.00011	0.00309 ± 0.00012	0.00297 ± 0.00011
Mo	-	0.00015 ± 0.00002	-
Pd	-	-	0.00037 ± 0.00004
Elements	**Concentration**		
	A2 (0-20 m) 0-5 cm	**A2 5-10 cm**	**A2 10-30 cm**
Fe	0.59115 ± 0.00029	0.46662 ± 0.00029	0.28995 ± 0.00021
Rb	0.00172 ± 0.00011	0.00148 ± 0.00010	0.00101 ± 0.00007
Sr	0.00486 ± 0.00018	0.00429 ± 0.00017	0.00328 ± 0.00012
I_2	0.00060 ± 0.00005	0.00078 ± 0.00006	0.00052 ± 0.00004
Zr	0.00393 ± 0.00014	0.00400 ± 0.00014	0.00296 ± 0.00011
Nb	-	0.00035 ± 0.00004	-
Elements	**Concentration**		
	A3 (20-70 m) 5-10 cm	**A3 0-5 cm**	**A3 10-30 cm**
Fe	0.34898 ± 0.00023	0.29394 ± 0.00111	0.86389 ± 0.00036
Rb	0.00133 ± 0.00008	0.00132 ± 0.00009	0.00249 ± 0.00014
Sr	0.00357 ± 0.00013	0.00388 ± 0.00015	0.00548 ± 0.00020
I_2	0.00054 ± 0.00004	0.00051 ± 0.00005	0.00096 ± 0.00007
Zr	0.00290 ± 0.00011	0.00329 ± 0.00012	0.00558 ± 0.00018
Tb	-	0.00566 ± 0.00109	-

Table 1 shows that there was no significant difference in the elemental composition of the elements present here between the waste impact zone and samples taken from the control zone. Therefore, it can be concluded that the alunite waste in this area caused only mechanical pollution of the territory. It would be more effective to use this waste, consisting of various types of rock, as an important raw material base for construction work, especially in the development of road and communication systems. It would be more profitable to clear the area of waste and also to use the mountain meadow pastures for livestock farming. In the future, in the development of the region's economy, especially in the use of skilled mining labor, it would be more appropriate to use it here to strengthen the forage base for agriculture, especially livestock farming. At the same time, for the ecological safety of the territory, it is important to develop all deposits using mining methods. The cessation of mining operations in recent years has led to the formation of sparse grass thickets on these hills. Removing waste from the area, as well as using mountain meadow pastures for livestock farming, will also play a significant role in strengthening our republic's food supply. In the future, this will play an even greater role in the region's economic development, particularly in utilizing its skilled labor force in the mining industry, as well as in providing reliable supplies for agriculture in the region. The development of all deposits using mining methods is a key factor in maintaining the region's environmental integrity.

Discussion

The conducted studies revealed a number of geochemically anomalous zones containing high concentrations of the heavy metals studied. The main areas of anomalously high concentrations are localized primarily near iron ore processing plants and mines. Intraprofile differentiation is characterized by heavy metal accumulation in the upper 0–17 cm soil layer, in gray-humus horizons. In the lower illuvial-textural horizons, at a depth of 70–80 cm, the anomalous zones are significantly reduced in size and manifest themselves more locally in spatial variation. The conducted research revealed that a total of 2.996 ha, or 0.013% of the territory of the Gadabay and Dashkasan regions on the northeastern slope of the Lesser Caucasus, were subject to technogenic pollution. In the studied areas, anthropogenic geosystems man-made giant landforms, waste heaps, roads, etc., formed as a result of the use of technogenic waste have significantly altered the natural environment, disrupting the soil and vegetation cover, soil formation, and hydrogeological processes. Due to a lack of air in the waste from old copper mines with a highly acidic environment (pH 1.6–2.0), the mineralization of organic matter ceases, making direct use of the waste in agriculture impossible. Considering that this figure will increase as a result of the commissioning of new deposits in the Dashkasan region, where 51.5% of the territory is subject to pollution, it is important to pay special attention to the use of new, more modern technologies. It would be more efficient to use existing waste, consisting of various types of rocks, as an important raw material base for construction work, especially in the development of road and transport infrastructure.

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Integrated Evaluation of Exodynamic Processes in the Nakhchivanchay Basin Based on Geological and Geophysical Indicators Using Gis and Remote Sensing Methods

Gultekin Hajiyeva[1], Ilahe Seyidova[1], Sevda Aliyeva[2*], Ulviyya Isgandarova[3], Mirnazim Seyidov[2]

Abstract: *In this study, the mechanisms of formation and distribution characteristics of exodynamic processes developing in the Nakhchivanchay basin over the territory were systematically investigated based on modern scientific methods. During the study, the geological structure, lithological composition, tectonic features, and geomorphological conditions of the territory were taken as the main objects of analysis. The intensity and spatial differentiation of the processes formed as a result of the interaction of these factors were widely evaluated. Within the framework of the study, the morphometric indicators of the territory were determined by applying digital relief models, satellite data and geographic information systems technologies. In particular, the degree of inclination of the slopes, exposure characteristics and the level of fragmentation of the relief were analyzed in detail. In addition, the distribution of structural linearities and tectonic faults was assessed using cartographic methods and sensitive areas in terms of risk were identified. The conducted analyses showed that erosion, landslides, denudation, and floods are observed more intensively mainly on steep slopes, in areas where weakly resistant rocks are distributed and in tectonically active zones. At the same time, climatic and hydrological factors, especially the amount of precipitation and the formation of surface runoff, play an important role in strengthening these processes. In addition, it was determined that anthropogenic impacts are also significant. Agricultural activity, improper land use and construction work lead to disruption of the natural balance in some areas and acceleration of processes. In particular, the weakening of vegetation cover further increases the risk of erosion.*

Keywords: *Nakhchivanchay basin, exodynamic processes, lithology, geological risk, tectonic faults, GIS, remote sensing*

[1]ARETN Institute of Natural Resources, PhD student, Baku, Azerbaijan
[2]Nakhchivan State University, PhD in Chemistry, Nakhchivan, Azerbaijan
[3]Nakhchivan State University, PhD in Geography, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: sevdaeliyeva@ndu.edu.az
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Naxçıvançay hövzəsində ekzodinamik proseslərin GIS və məsafədən zondlama metodlarından istifadə etməklə geoloji və geofiziki göstəricilər əsasında inteqral qiymətləndirilməsi

Gültəkin Hacıyeva[1], İlahə Seyidova[1], Sevda Əliyeva[2*], Ülviyyə İsgəndərova[3], Mirnazim Seyidov[2]

Xülasə: *Bu tədqiqatda Naxçıvançay hövzəsində inkişaf edən ekzodinamik proseslərin formalaşma mexanizmləri və yayılma xüsusiyyətləri müasir elmi metodlar əsasında sistemli şəkildə araşdırılmışdır. Tədqiqat zamanı ərazinin geoloji quruluşu, litoloji tərkibi, tektonik xüsusiyyətləri və geomorfoloji şəraiti əsas təhlil obyektləri kimi götürülmüşdür. Bu amillərin qarşılıqlı təsiri nəticəsində formalaşan proseslərin intensivliyi və məkan üzrə diferensiasiyası geniş şəkildə qiymətləndirilmişdir. Tədqiqat çərçivəsində rəqəmsal relyef modelləri, peyk məlumatları və coğrafi informasiya sistemləri (GIS) texnologiyalarının tətbiqi ilə ərazinin morfometrik göstəriciləri müəyyən edilmişdir. Xüsusilə, yamacların meyillilik dərəcəsi, ekspozisiya xüsusiyyətləri və relyefin parçalanma səviyyəsi ətraflı təhlil edilmişdir. Bununla yanaşı, struktur lineamentlərin və tektonik qırılmaların paylanması kartoqrafik metodlarla qiymətləndirilmiş, risk baxımından həssas ərazilər müəyyən edilmişdir. Aparılmış təhlillər göstərmişdir ki, eroziya, sürüşmələr, denudasiya və sel hadisələri əsasən dik yamaclarda, zəif dayanıqlı süxurların yayıldığı sahələrdə və tektonik cəhətdən aktiv zonalarda daha intensiv müşahidə olunur. Eyni zamanda, iqlim və hidroloji amillər, xüsusilə yağıntının miqdarı və səthi axının formalaşması bu proseslərin güclənməsində mühüm rol oynayır. Bundan əlavə, antropogen təsirlərin də əhəmiyyətli olduğu müəyyən edilmişdir. Kənd təsərrüfatı fəaliyyəti, torpaqdan qeyri-səmərəli istifadə və tikinti işləri bəzi ərazilərdə təbii tarazlığın pozulmasına və proseslərin sürətlənməsinə səbəb olur. Xüsusilə, bitki örtüyünün zəifləməsi eroziya riskini daha da artırır.*

Açar sözlər: *Naxçıvançay hövzəsi, ekzodinamik proseslər, litologiya, geoloji risk, tektonik qırılmalar, GIS, məsafədən zondlama*

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[1]ARETN Təbii Sərvətlər İnstitutu, doktorant, Bakı, Azərbaycan
[2]Naxçıvan Dövlət Universiteti, kimya üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[3]Naxçıvan Dövlət Universiteti, coğrafiya üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: sevdaeliyeva@ndu.edu.az
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Introduction

There is a close relationship between the development of relief and slope processes in mountainous and tectonically active areas. Various studies have shown that tectonic uplifts, lithological properties of rocks and morphostructural elements play an important role in the formation of slope instability (Abdelkarim et al., 2025; Alizadeh et al., 2016). The geological structure of Azerbaijan is distinguished by complex structural features, and here, along with endogenous processes, exogenous factors also affect the transformation of the relief (Erener et al., 2016; Bababayli et al., 2026). The application of geophysical methods provides significant results in determining the underground structure and potential risk zones (Blakely, 1995; Chen et al., 2016; Corominas et al., 2013; Eastman, 2012).

Studies conducted in the field of landslide assessment show that a systematic and multiparameter approach is required for objective determination of risk and hazard (Eppelbaum et al., 2014; Guzzetti et al., 1999; Horton, 1945). Preparation of landslide inventories, spatial-temporal analysis of existing events and statistical evaluation increase the reliability of models (Hummatov, 2025). Climate change, especially increased precipitation intensity and changes in temperature regime, lead to the intensification of slope processes (IPCC, 2023). The development of drainage networks, erosion, and flood events are also among the factors that directly affect slope stability (Iskenderova et al., 2025; Kearey et al., 2002). Digital elevation models and morphometric analysis methods are widely used in determining landslide susceptibility. Indicators such as slope angle, exposure, curvature, flow direction and accumulation area are considered key parameters in mapping risk zones (Leulalem et al., 2020; Lowrie, 2007; Malczewski, 2006). Processing of high-precision topographic data allows for a more detailed analysis of geomorphological features (Mandal, 2018). At the modern stage, the integration of GIS and remote sensing technologies has made the preparation of landslide susceptibility maps more effective. Multi-criteria decision-making approaches, especially the Analytical Hierarchy Process (AHP), are widely used in determining the relative weight of various factors (Montgomery & Dietrich, 1994; Mutlu et al., 2019; Moore et al., 1991; Qiqing & Wenping, 2017; Reichenbach et al., 2018). Statistical models and forecasting methods act as important tools in landslide hazard assessment (Riley et al., 1999; Shahabi & Hashim, 2015). Special software and geographic information systems create an important technical basis for implementing these processes (Shano et al., 2020). Thus, a review of the existing literature shows that a comprehensive analysis of geological structure, climatic factors, hydrological characteristics and anthropogenic impacts is essential for studying landslides and related geomorphological processes. The combined application of geophysical surveys, digital terrain analysis and GIS-based multi-criteria modeling methods allows for more accurate results (Tarboton, 1997; Tarolli et al., 2012; Telford et al., 1990; Saaty, 2014; Wilson & Gallant, 2000).

Methods

Exodynamic processes play a leading role in the formation of the Earth's surface, leading to the development of relief, land cover degradation and landscape transformation. Especially in mountainous and semi-desert conditions, these processes take on an intensive character and lead to an increase in natural risks. The Nakhchivanchay basin is one of the regions with high dynamics from a geomorphological and geological point of view. Here, the complex tectonic structure, poorly cemented rocks and intensively fragmented relief create favorable conditions for the activation of exodynamic processes. The application of modern GIS and remote sensing methods allows for a more accurate determination of the spatial regularities of these processes. The main goal of the study is a comprehensive assessment of exodynamic processes in the Nakhchivanchay basin based on geological and geophysical indicators.

Research object and natural-geographical conditions

The Nakhchivanchay basin is located in the southwestern part of the Lesser Caucasus and is part of a complex geological-geomorphological system on a regional scale. The interaction of tectonic structure, lithological diversity and climatic factors plays a decisive role in the formation of the basin relief. The hypsometric structure of the territory is characterized by a sharp vertical discontinuity; absolute heights vary between 2800–3200 m in the upper parts of the basin and 700–900 m in the lower reaches. These differences create conditions for the uneven distribution of the intensity of slope processes over space. From a geological point of view, the Nakhchivanchay basin is characterized as an area where Mesozoic and Cenozoic rock complexes are widespread. Jurassic and Cretaceous carbonate rocks predominate mainly in the mountainous areas of the basin and have a high degree of fracture. These features increase the susceptibility of rocks to physical weathering and karstification, creating favorable conditions for the development of avalanche and landslide processes. Paleogene–

Neogene terrigenous sediments are more common in foothills and plains and play a key role in the formation of surface washing, linear erosion and flood flows.

Although the local distribution of volcanic rocks relatively increases lithological stability, in the zones where these rocks are cut by tectonic faults, mechanical stability decreases and the intensity of exodynamic processes increases. In this regard, the lithological factor, not alone, but together with the tectonic structure, acts as one of the main factors determining the spatial distribution of exodynamic processes. From a tectonic point of view, the territory is located in an active structural zone and is characterized by regional and local fault systems of various directions. These faults, in addition to controlling the morphostructural development of the relief, play an important role in the localization of exodynamic processes. The degree of fragmentation of rocks increases along the fault zones, the possibilities of water infiltration increase, and as a result, landslides, floods and erosion processes develop more intensively. Many studies show that areas close to faults are considered more dangerous zones in terms of exodynamic risk.

The climatic conditions are characterized by sharply continental and semi-desert features. The annual precipitation varies spatially, and in mountainous areas it is 400–500 mm, and in plain zones it is 200–300 mm. The main part of the precipitation falls on the spring and autumn months and is of the nature of short-term, but intense downpours. Such a precipitation regime enhances surface runoff on the slopes, weakens the stability of the soil cover and increases the frequency of flood events. High temperature amplitude and strong evaporation lead to a decrease in soil moisture in the summer season, and rapid saturation of the soil in the autumn and spring seasons, which plays an important role in the activation of landslide processes. Thus, the climatic factor, together with lithological and tectonic factors, acts as the main natural and geographical condition that increases the intensity of exodynamic processes. In general, the natural and geographical conditions of the Nakhchivanchay basin — complex relief, diverse lithological complexes, active tectonic faults and continental climate features - determine the high intensity and spatially differential development of exodynamic processes. These features make the basin an important model area for geological risk assessment and GIS-based monitoring studies.

Materials and methods

Remote sensing, cartographic and field data obtained from various sources were used in a complex manner for the study. The data used were aimed at assessing the spatial distribution, intensity of exodynamic processes and the factors determining them.

The main morphometric analyses in the study were carried out on the basis of a digital relief model (DEM) with a spatial resolution of 30 m originating from SRTM (Shuttle Radar Topography Mission). DEM data were used to calculate the main geomorphometric indicators such as slope inclination, exposure and degree of relief fragmentation. Geological and tectonic maps were used to analyze the lithological composition of the region, stratigraphic complexes and tectonic fault systems. Based on these maps, the distribution areas of lithological units and the spatial density of fault zones were determined, and their impact on the localization of exodynamic processes was assessed.

Landsat 8 OLI/TIRS and Sentinel-2 MSI satellite images were used as remote sensing data. These images played an important role in determining the state of landscape cover, surface changes and erosion traces. Normalized Difference Vegetation Index (NDVI) and land surface indicators were calculated based on satellite images. Topographic and hydrographic materials were used to assess the structure of the river network, drainage density, and water erosion processes. Hydrographic data served as an additional source of information in the analysis of flood risk and the intensity of slope processes.

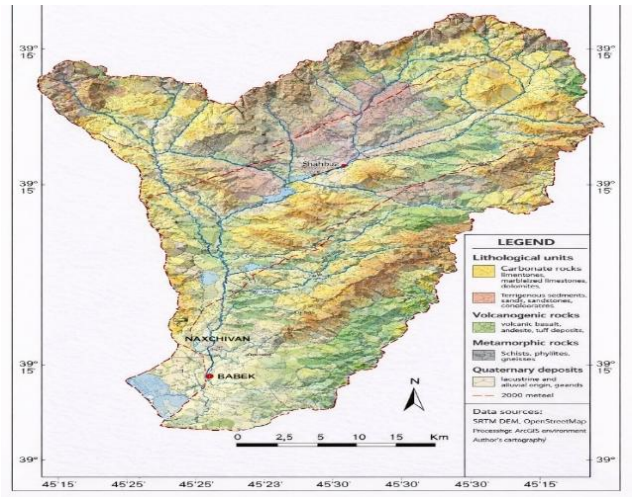

Figure 1

Lithological and tectonic fault map of the Nakhchivanchay basin (scale 1:180,000)

The compiled "Lithological and Tectonic Fault Map of the Nakhchivanchay Basin" reflects the geological structure and tectonic features of the Nakhchivanchay Basin, one of the main hydrographic units of the Nakhchivan Autonomous Republic, in general. The map was prepared at a scale of 1:180,000 and allowed for the assessment of the spatial distribution of lithological units and tectonic structures at the regional level. The map presents the main lithological complexes distributed in the basin area in a generalized form using conventional symbols and color shades. These rock complexes play an important role in the formation of the relief, the movement of surface and groundwater, as well as the development of exodynamic processes. Lithological diversity reflects the complexity of the geological development history of the basin and acts as one of the main factors in explaining the geomorphological features of the area. The tectonic faults shown on the map demonstrate that the basin is located in a structurally active zone. The spatial location of these faults is considered to be the main structural elements influencing the formation of the hydrographic network, the degree of fragmentation of the relief and the intensity of geodynamic processes. The presence of tectonic elements determines the spatial differentiation of risks in the area. In general, the compiled map creates a general idea of the geological and tectonic features of the Nakhchivanchay basin and plays the role of a reliable cartographic basis for the assessment of exodynamic processes, identification of geological risks, as well as for territorial and landscape planning. The use of modern geographic information technologies in the preparation of the map increases its scientific and practical significance.

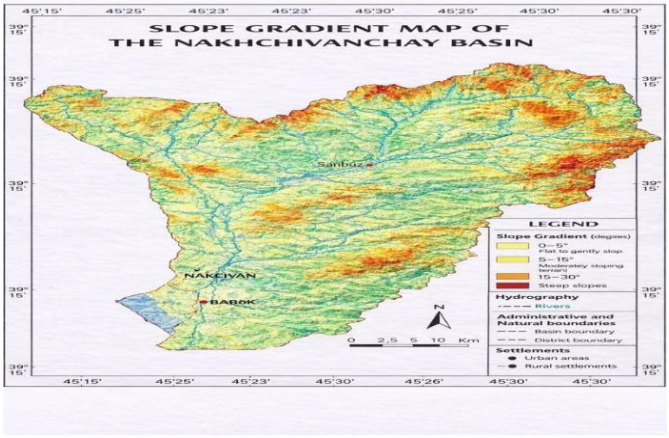

Figure 2

Slope Gradient Map of the Nakhchivanchay Basin

The role of slope gradient in the development of exodynamic processes. In the Nakhchivanchay Basin, the morphometric characteristics of the relief, in particular slope gradient, are considered to be one of the main factors determining the spatial distribution and intensity of exodynamic processes. The slope gradient map calculated based on the digital relief model (SRTM, 30 m spatial resolution) shows that the geomorphological conditions within the basin are highly heterogeneous (Figure 2). Areas with a slope of 0–5° are mainly represented by river valleys, terraced plains and accumulative forms. Since the kinetic energy of the surface flow is weak in these zones, erosion processes are limited in nature, and sediment accumulation prevails. Such relief conditions are characterized by fluvial accumulation and relative stability of the soil cover. Slopes located in the range of 5–15° and 15–30° constitute the most widespread morphometric zone in the basin. As a result of the increase in the speed of surface runoff in these areas, the processes of ravine erosion, slope washing and soil loss become more active. Studies show that it is in this slope range that the hydrological response is formed more quickly and erosion processes are more sensitive to climatic factors. Areas with a slope of more than 30° are characterized by high erosion and landslide potential. These zones are mainly concentrated in mountainous areas, along tectonic faults and in areas where lithologically weak rocks are distributed. With an increase in the slope angle, the effect of gravity increases and favorable conditions are created for mass movements (landslides, avalanches, rock flows). These features are clearly observed in geodynamically active areas of the Nakhchivanchay basin.

Thus, the slope inclination map is not only an important analytical tool for understanding the spatial structure of exodynamic processes in a basin, but also has practical importance in terms of erosion risk assessment, land use planning, and natural hazard management. Morphometric analysis of the relief. It was carried out using DEM-based GIS methods. In this framework, such main indicators as slope, aspect, degree of relief fragmentation (Terrain Ruggedness Index – TRI) and drainage density were calculated. These parameters play a fundamental role in assessing the intensity and spatial differentiation of exodynamic processes. The results of the slope analysis show that weak and medium slopes prevail in the Nakhchivanchay basin, which mainly corresponds to foothill and plain relief forms. At the same time, the spread of medium and high slopes is observed in the upper mountainous parts of the basin. As a result of the acceleration of surface runoff, erosion, ravinement and landslide processes develop more intensively in these areas. The close relationship between slope inclination and erosion processes has been widely proven in various studies.

The exposure analysis allowed us to assess the distribution of solar radiation and microclimate differences. High evaporation and reduced soil moisture on southern and southwestern slopes act as one of the main factors increasing the risk of erosion. Northern-facing slopes have more humid conditions and show relative geomorphological stability. TRI indicators characterize the morphological contrast of the relief. In the Nakhchivanchay basin, especially in areas with intensive tectonic faults, an increase in TRI values is observed, which determines the localization of exodynamic processes.

Table 1
Geomorphological interpretation of slope inclination classes

Slope inclination (°)	Geomorphological characteristic	Exodynamic risk
0–5°	Plains and alluvial areas	Low
5–15°	Foothill zones	Medium
15–30°	Mountainous areas	High
>30°	Rigidly dissected relief	Very high

Note: The area distribution was assessed based on quality indicators in accordance with DEM-based GIS analyses.

GIS-based multi-criteria assessment (AHP method). In order to identify potential development areas of exodynamic processes in the Nakhchivanchay basin, a GIS-based multi-criteria decision-making (MCDA) approach was applied. This approach allows for the consideration of the combined effects of various natural-geographical and geological factors and an objective assessment of risks by location. The Analytical Hierarchy Process (AHP) method was used within the framework of the study (Saaty, 2014). AHP is one of the widely applied scientific methods in terms of hierarchical structure of complex problems, determination of the relative importance of factors and systematic analysis of mutual influence.

The assessment process was carried out in three stages:

1. Selection of factors and preparation of thematic layers. The main natural-geographical and geological factors affecting the formation of exodynamic processes were identified. The selection of factors was carried out on the basis of scientific literature, physical-geographical characteristics of the region and existing databases. The selected factors were converted into thematic layers in the GIS environment, and slope inclination, height and degree of relief fragmentation were calculated as morphometric indicators based on DEM. Lithological and tectonic data were digitized from geological maps, and the hydrographic network was evaluated by distance analysis. All layers were brought to the same coordinate system and aligned with spatial accuracy.

2. Calculation of AHP weight coefficients and GIS integration. Pairwise comparisons between the selected factors were carried out based on the Analytical Hierarchy Process (AHP) method. At this stage, the influence of each factor relative to the other was assessed on a scale of 1–9, as a result, the relative weight coefficients of the factors were determined. For example, a weight value of 0.35 was calculated for slope inclination, 0.30 for lithological structure, 0.20 for tectonic fracture density, and 0.15 for proximity to the hydrographic network. The Consistency Ratio (CR) was checked and found to be below 0.1, which indicates that the logical sequence of the results is ensured

3. Integration of weighted layers in the GIS environment and compilation of the final risk map

In the third stage, the weighting coefficients calculated were applied to thematic GIS layers and a final risk map was prepared using the Weighted Overlay algorithm. The digital values of each factor in GIS were multiplied by the weighting coefficient to determine the overall risk indicator for the areas. As a result, low, medium and high risk zones were identified in the Nakhchivanchay basin, and the spatial distribution of these zones was visually displayed on the map. The final risk map was consistent with the geomorphological and geological characteristics of the region and demonstrated that the assessment was scientifically sound.

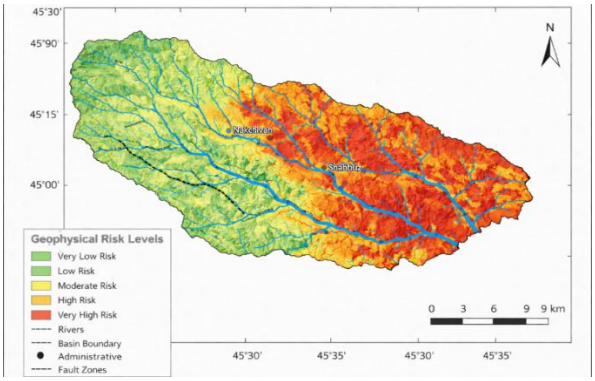

Figure 3
Final risk map of the Nakhchivanchay River Basin

This map was prepared in a Geographic Information Systems (GIS) environment to assess risk levels in the Nakhchivanchay River Basin. In the third stage of the study, pre-calculated weighting factors were applied to appropriate thematic layers and a final risk map was compiled based on the Weighted Overlay method. The main factors affecting the formation of risk (slope of the relief, geological structure, soil cover, land use forms, density of the hydrographic network, etc.) were reclassified on a single scale and integrated according to their relative importance. As a result, the area was divided into very low, low, medium, high and very high risk classes. As can be seen from the map, high and very high risk zones are mainly concentrated in areas with mountainous, fragmented relief and complex geological conditions. Low risk areas are mainly characterized by plain areas and more stable landscape features.

Table 2
AHP weighting factors and GIS integration for the Nakhchivanchay basin

Factor	Weighting coefficient	Description	Reclassification / category in GIS	Risk impact
Slope inclination	0.35	The risk of surface erosion and landslides increases in areas with high slope angles. Areas with slope angles between 15–30° are classified as medium risk, and >30° are classified as high risk.	0–5° → 1, 5–15° → 2, 15–30° → 3, >30° → 4	High propensity → high risk; medium propensity → medium risk
Lithological structure	0.30	Mechanical strength and resistance to erosion of rocks. Weakly cemented clay and terrigenous rocks are more susceptible, while strong carbonate and volcanic rocks are less at risk.	Strong rock → 1, Medium rock → 2, Weak rock → 3	Weak rock → high risk; strong rock → low risk
Tectonic fault density	0.20	The density of fault zones increases the fragmentation of rocks and increases the likelihood of landslides. The risk is considered higher in areas with a high fracture density.	Low → 1, Medium → 2, High → 3	High fracture density → high risk
Proximity to hydrographic network	0.15	Surface erosion and soil displacement are more intense in areas near rivers and streams..	>500 m → 1, 200–500 m → 2, <200 m → 3	Areas close to rivers → high risk; remote areas → a

This table was prepared for GIS-based multi-criteria assessment of exodynamic processes in the Nakhchivanchay basin. The table takes into account four main factors – slope, lithological structure, tectonic fracture density and proximity to the hydrographic network – and evaluates the impact of each on exodynamic processes using the Analytical Hierarchy Process (AHP) method. Relative weightings were determined for each factor, and the consistency ratio was calculated to confirm the logical sequence of the results. The table also presents reclassification values in the GIS environment, which allows for the calculation of risk zones using the Weighted Overlay algorithm.

The risk impact column in the table simply explains how each factor affects the overall risk. Thus, areas with high slope, weak lithological rocks, high fracture density and proximity to rivers are

considered high risk zones. The table also shows the distribution of medium and low risk areas, which is consistent with the geomorphological characteristics of the basin. Overall, this table, combining AHP weighting factors and GIS integration, provides an objective and scientifically sound assessment of potential development areas of exodynamic processes in the Nakhchivanchay basin.

The results showed that the risk zones for exodynamic processes in the Nakhchivanchay basin are divided into low, medium and high categories. High risk zones mainly coincide with areas with high slope inclination, poorly cemented rocks, density of fault zones and close to river valleys. Medium risk zones cover areas with more balanced slopes and solid lithological rocks, while low risk zones mainly consist of areas with low slopes and stabilized geological structures. This spatial distribution is consistent with the geomorphological characteristics of the region and confirms that GIS–AHP integration is a reliable and scientifically sound method for assessing exodynamic processes. The obtained data are of practical importance for land management, infrastructure planning, and reducing erosion and landslide risks. The weighted summation method in the GIS environment takes into account the interaction of different factors and, as a result, makes it possible to conduct a multi-criteria integrated assessment, not just on a single factor.

Remote sensing data processing and NDVI analysis

Landsat 8 OLI/TIRS and Sentinel-2 MSI satellite images were used as remote sensing data. Scenes covering the vegetation period and with a cloudiness level of less than 10% were selected for analysis. Satellite images were processed in a geographic information system environment after radiometric and atmospheric corrections. A normalized vegetation index (NDVI) was calculated based on satellite images. NDVI indicators served as the main indicator in determining the state of landscape cover, the degree of soil surface protection, and potential erosion zones. Areas characterized by low NDVI values were mainly observed in areas with high slope inclination and weak vegetation cover, which is considered a factor increasing the intensity of exodynamic processes in those areas. NDVI results were integrated with slope inclination, lithological structure, and proximity to the hydrographic network layers and used in GIS-based analyses and played an important role in the formation of risk zones. The results obtained confirmed the existence of a close spatial relationship between vegetation cover and erosion and landslide processes.

Figure 4
Vegetation Density (NDVI) Map of the Nakhchivanchay River Basin

The NDVI (Normalized Density Index) map of the Nakhchivanchay River Basin was compiled based on Landsat 8 OLI/TIRS and Sentinel-2 MSI satellite images. This index allows us to assess the spatial distribution, density, and condition of the landscape surface of the area. Areas with high NDVI values are mainly characterized by river valleys, irrigated agricultural fields, and foothill zones, which indicates that the vegetation cover in these areas is relatively dense and continuous.

Areas with low NDVI values are mainly observed in mountainous, arid, and exposed rock zones. These areas are characterized by poor vegetation cover, bare soil, and rocky landscapes. In these areas where vegetation is poorly developed, the intensity of surface washing, erosion, and landslide processes is higher. Especially in areas with high slope inclination and lithologically weakly consolidated rocks, low NDVI indicators create favorable conditions for exodynamic processes. Analysis of the NDVI map shows that vegetation plays an important role in landscape stability and directly affects the spatial variability of landslide risk. In areas with rich vegetation, slope stability increases, and the probability of erosion and landslides decreases. In this regard, NDVI indicators have been used as an important factor in a GIS-based multi-criteria assessment model and have played a reliable indicator in determining landslide risk zones

Analysis of geophysical indicators and structural-tectonic interpretation In order to determine the relationship of exodynamic processes with deep geological factors in the Nakhchivanchay basin, structural-tectonic interpretation of geophysical field indicators was carried out. This approach allows to reveal weakening zones, tectonic faults and structural heterogeneities in the internal structure of the earth's crust and plays an important role in understanding the genetic causes of surface geomorphological processes. Within the framework of the study, magnetic anomalies, gravity gradients and seismic fault zones were analyzed as the main geophysical parameters. These indicators reflect the differences in the physical properties of rock complexes, structural disturbances and tectonic activity.

• Magnetic anomalies: They indicate changes in the magnetic susceptibility of rocks. High-amplitude magnetic anomalies usually correspond to cracked, fractured and tectonically affected zones of rock massifs. In these areas, mechanical stability decreases and favorable conditions arise for exodynamic processes such as landslides and avalanches.
• Gravity gradients: They indicate the unevenness of the distribution of subsurface mass and play an important role in identifying lithological boundaries, tectonic faults, and deep structural elements. Zones of sharp changes are characterized by weakened and heterogeneous rock complexes, where the redistribution of surface stresses intensifies erosion and landslide processes.

• Seismic fault zones: They are a direct indicator of tectonic activity. In areas with dense seismic lines, the structural integrity of the rocks is disrupted and the fracture systems expand, as a result of which the risk of landslides increases. Analysis in a GIS environment has shown that zones of high seismic activity often coincide with areas of high slope inclination and fragmentation of the relief.

As a result of the comprehensive analysis, it was determined that high geophysical anomalies characterize weakened rock zones, and these areas should be assessed as potential risk zones for exodynamic processes. Thus, the structural-tectonic interpretation of geophysical indicators creates a scientific basis for assessing landslide and erosion hazards and significantly increases the accuracy of GIS-based multi-criteria models.

4. Verification of Results and Statistical Analysis

The prepared GIS–AHP-based exodynamic risk model was not limited only to thematic mapping but was also verified by statistical and empirical methods. To assess the adequacy of the model, ROC curve, AUC indicator, inter-factor correlation analysis, and field verification were carried out

ROC and AUC Analysis

Receiver Operating Characteristic (ROC) analysis was applied to assess the predictive ability of the risk map. This method is widely used in landslide and erosion risk mapping and allows for an

objective assessment of the classification accuracy of the model (Akgun et al., 2014; Shrestha & Kazama, 2007).

AUC (Area Under Curve) indicator calculated for the model:

AUC = 0.84
The AUC value higher than 0.8 indicates that the model has a high discrimination ability. This result shows that the multi-criteria GIS–AHP integration can reliably identify the potential spread zones of exodynamic processes in the Nakhchivanchay basin.

Distribution of Risk Zones by Area

The final risk map, prepared based on the Weighted Overlay algorithm, was divided into five categories.

Table 3
The distribution of risk zones by area is as follows

Risk class	Ratio to total area (%)
Very low	18 %
Low	25 %
Medium	29 %
High	20 %
Very high	8 %

The results show that approximately 28% of the basin area is included in the high and very high risk zones. These areas mainly coincide with zones of high slope inclination (>30°), poorly cemented rocks and increased tectonic fault density.

Statistical Correlation Between Factors

Spearman correlation analysis was performed to assess the relative influence of the main factors affecting the formation of exodynamic processes.

Table 4
Spearman Correlation Analysis of Exodynamic Controlling Factors

Factor	Correlation coefficient(r)	Statistical
Slope inclination	0.71	$p < 0.01$
Lithological weakness	0.63	$p < 0.01$
Fracture density	0.58	$p < 0.05$
Hydrographic proximity	0.49	$p < 0.05$
NDV	-0.66	$p < 0.01$

Slope inclination showed the highest positive correlation, which confirms the leading role of the morphometric factor. The negative correlation with NDVI indicates a decrease in the risk level with increasing vegetation density. This result scientifically justifies the existing relationship between slope stability and vegetation cover (Montgomery & Dietrich, 1994).

Field Verification

In order to verify the suitability of the model in real conditions, 42 exodynamic process points (landslides and intensive erosion areas) were compared with the risk map based on GPS coordinates.

Table 5
Field-Based Validation of Risk Classification

Risk category (%)	Observation share
Very high	36 %
High	33 %
Medium	21 %
Low	10 %

The fact that 69% of the observations are located in high and very high risk zones confirms the adequacy and prognostic reliability of the model. This result shows the effectiveness of the Analytical Hierarchy Process method in geological risk mapping

Scientific Innovation

The conducted multi-criteria assessment shows that the spatial distribution of exodynamic processes in the Nakhchivanchay basin is mainly determined by the interaction of morphometric, lithological and structural-tectonic factors.

The main scientific innovation of this study is the following:
Integration of morphometric, lithological, tectonic and NDVI indicators in a single GIS–AHP model;
Statistical validation of the model by ROC–AUC analysis;
Determination of the quantitative areal distribution of risk zones;
Demonstration of the spatial correspondence of structural-tectonic vulnerability zones with exodynamic risk.
The obtained results have practical significance in terms of engineering-geological planning, risk assessment of infrastructure projects and land use optimization.

Results and discussion

The conducted studies show that the formation of natural processes in the Nakhchivanchay basin directly depends on the geomorphological and geological characteristics of the area. The structural features of the relief, especially the degree of inclination of the slopes and the rock composition, have a significant impact on the intensity of exodynamic processes. In areas where the slope angle increases, the surface flow intensifies, which leads to the activation of erosion and slope processes. In areas where sedimentary rocks with poor mechanical stability are widespread, the rate of relief erosion is higher. In these areas, the soil and rock cover are more sensitive to external influences, resulting in a violation of the geomorphological balance. Under such conditions, denudation processes expand and noticeable changes occur in the morphological structure of the landscape. This weakens the natural sustainability of the area and increases its sensitivity to anthropogenic influences.

In areas with complex tectonic structures, the level of fragmentation of the relief is higher. Structural weaknesses are formed along the fault lines, which creates favorable conditions for the activation of geodynamic processes. The geophysical differences observed in these zones indicate an increased potential risk level of the area. According to the results, tectonic elements act as one of the main determining factors in the spatial distribution of risk zones. The application of remote sensing materials and geographic information systems has created significant advantages in the analysis of the spatial structure of processes. Analyses based on digital models have allowed for an accurate assessment of relief indicators and differentiation of risk levels. The results obtained show that high-risk areas are mainly concentrated in mountainous and structurally active zones, while in relatively stable areas the risk indicators are low. In general, the analyses conducted prove that geophysical risks in the Nakhchivanchay basin have an uneven spatial distribution. The prepared map and the results obtained are of great importance in terms of scientific assessment of the area, landscape planning, and early identification of pote

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Delayed Aging as a Biological Phenomenon: The Role of Biochemical and Cellular Markers

Gular Zeynalova

Abstract. *This study is devoted to a comprehensive assessment of biochemical, hormonal, and cellular hematological parameters in centenarians and their immediate relatives to identify their potential role in the development of the delayed aging phenotype. The study included centenarians and their relatives living in the Goychay region of Azerbaijan, a region where longevity has not previously been studied. For comparative analysis, parameters from control groups (individuals unrelated to centenarians) were used. The study analyzed lipid peroxidation parameters and the state of the blood antioxidant system, steroid hormone levels (progesterone and dehydroepiandrosterone), and a number of cellular hematological parameters. The study results showed that centenarians develop a more favorable oxidative profile, characterized by reduced lipid peroxidation activity and relatively preserved antioxidant protection. The identified hormonal status characteristics indicate the potential role of steroid hormones in maintaining adaptive mechanisms and metabolic homeostasis during aging. Analysis of cellular and hematological parameters indicates the preservation of the functional state of the blood system, which can be considered an additional component of the healthy aging phenotype. These data confirm the importance of a comprehensive approach to studying aging biomarkers and expand our understanding of the molecular and biochemical foundations of healthy aging in humans.*

Keywords: *centenarians, aging, aging biomarkers, lipid peroxidation, antioxidant system, oxidative stress, progesterone, dehydroepiandrosterone, hematological parameters, hereditary factors, Azerbaijan*

Academician Abdulla Garayev Institute of Physiology, Baku, Azerbaijan
E-mail: inciqizim65@gmail.com
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Gecikmiş yaşlanma bioloji fenomen kimi: Biokimyəvi və hüceyrə markerlərinin rolu

Gülər Zeynalova

Xülasə. *Təqdim olunmuş məqalə uzunömürlülərdə və onların yaxın qohumlarında biokimyəvi, hormonal və hematoloji parametrlərin kompleks qiymətləndirilməsinə həsr olunmuşdur. Aparılmış tədqiqatın məqsədi ləngimiş qocalma fenotipinin formalaşmasında tədqiq olunan biokimyəvi göstəricilərin mümkün rolunu müəyyən etməkdir. Tədqiqata Azərbaycan Respublikasının Göyçay rayonunda yaşayan uzunömürlülər və onların qohumları cəlb edilmişdir. Belə ki, qeyd olunan regionda uzunömürlülük səviyyəsi əvvəllər tədqiq olunmamışdır. Tədqiqatda müqayisəli analiz məqsədilə nəsildə uzunömürlü olmayan şəxslərdən ibarət nəzarət qrupunun göstəricilərindən də istifadə edilmişdir.*

Aparılmış tədqiqatlar zamanı tədqiq olunan qruplarda lipidlərin peroksid oksidləşməsi göstəriciləri və qan antioksidant sisteminin vəziyyəti, steroid hormonların (progesteron və dehidroepiandrosteron) səviyyələri, eləcə də bir sıra hematoloji parametrlər təhlil olunmuşdur. Tədqiqatın nəticələri göstərmişdir ki, uzunömürlü şəxslərdə lipidlərin peroksid oksidləşmə proseslərinin aktivliyinin azalması və antioksidant müdafiə sisteminin nisbi qorunması ilə xarakterizə olunan daha əlverişli oksidativ profil formalaşır. Hormonal statusun müəyyən olunmuş xüsusiyyətləri steroid hormonların qocalma şəraitində adaptasiya mexanizmlərinin və metabolik homeostazın saxlanılmasında potensial rolunu göstərir. Hematoloji göstəricilərin analizi zamanı isə qan sisteminin funksional vəziyyətinin qorunub saxlanılmasını aşkar olunmuşdur, bu da sağlam qocalma fenotipinin əlavə komponenti kimi qiymətləndirilə bilər. Beləliklə, tədqiqat zamanı alınmış nəticələr qocalma biomarkerlərinin öyrənilməsində kompleks yanaşmanın əhəmiyyətini təsdiqləyir və orqanizmin sağlam qocalmasının molekulyar-biokimyəvi əsasları haqqında biliklərin genişləndirilməsinə zəmin yaradır.

Açar sözlər: *uzunömürlülər, qocalma, qocalma biomarkerləri, lipidlərin peroksid oksidləşməsi, orqanizmin antioksidant sistemi, oksidativ stress, progesteron, dehidroepiandrosteron, hematoloji göstəricilər, irsi amillər, Azərbaycan*

Akademik Abdulla Qarayev adına Fiziologiya İnstitutu, Bakı, Azərbaycan
E-poçt: inciqizim65@gmail.com
Daxil oldu: 22 Fevral 2026; Qəbul edildi: 17 Aprel 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

A current area of research in modern gerontology is the search for and comprehensive evaluation of aging biomarkers that reflect the mechanisms of longevity and the preservation of functional reserves in old age. The classic definition of an aging biomarker was proposed by Baker and Sprott back in 1988: a biological parameter (or several parameters) that, in the absence of overt pathology, more accurately predicts functional capacity in late life than chronological age (Baker & Sprott, 1988). According to modern research, an ideal marker should reflect the fundamental mechanisms of aging, demonstrate reproducibility across different populations, be applicable across different tissues and species, respond to geroprotective interventions, and predict clinically significant outcomes (Herzog et al., 2025; Moqri et al., 2023).

One of the early attempts to systematize objective indicators of healthy aging was the work of British researchers led by J. Lara (Lara et al., 2015). The work of Lara et al. (2015) was an important step toward standardizing the assessment of healthy aging and is still cited in reviews and consensus documents on aging biomarkers. In their work, the authors proposed a panel of biomarkers focused on assessing the preservation of the body's functional capacity during aging, and not just the absence of disease (Lara et al., 2015). It should be noted that the panel of Lara et al. (2015) represents an important step in the evolution of ideas about aging biomarkers, emphasizing the priority of functional indicators over purely laboratory ones. The criteria for selecting the "ideal" biomarker have remained unchanged since the 2010s, but in 2025, a Delphi method (three rounds, 60 experts from different countries) was used to reach consensus on the biomarkers most suitable as endpoints in anti-aging studies (Perri et al., 2025). A three-stage Delphi study was conducted using an online platform. In the first round, expert panel members proposed candidate aging biomarkers. In the second and third rounds, they voted on 500 initial statements (yes/no) concerning 20 aging biomarkers. Panel members could abstain from voting on biomarkers outside their expertise. Consensus was reached when ≥70% agreement was reached on a biomarker statement. Over the course of three rounds, consensus was

reached on 14 biomarkers covering physiological (e.g., insulin-like growth factor 1, growth differentiation factor-15), inflammatory (e.g., high-sensitivity C-reactive protein, interleukin-6), functional (e.g., muscle mass, muscle strength, grip strength, Stand-up and Go test, gait speed, standing balance test, frailty index, cognitive health, blood pressure), and epigenetic (e.g., DNA methylation/epigenetic clock) domains. Expert consensus identified 14 potential biomarkers of aging that could be used as outcome measures in intervention studies. (Perri et al., 2025).

Summarizing current literature, it can be shown that the main approaches to biomarker classification can be divided into functional, molecular genetic, epigenetic, and biochemical. Currently, there are two main theories of aging: genetic and cellular damage, and neither theory can ignore the role of mitochondria. The free-radical theory of premature aging is widely accepted, positing that aging occurs due to the accumulation of cellular damage caused by free radicals over time. The accumulation of large amounts of such damage in cells leads to disruption of their normal functioning (function), followed by changes consistent with aging and leading to disease (Koltan & Medvedev, 2018). Oxygen toxicity and the activity of oxygen-reducing intermediates necessitate the constant functioning of specialized antioxidant defense mechanisms in the body, which operate at the level of molecules, cells, tissues, organs, and the body as a whole, maintaining homeostasis. The antioxidant system (AOS) is the body's most important nonspecific defense system, quickly responding to changing external conditions. The balance between lipid peroxidation (LP) and antioxidant activity (AOA) reflects the body's adaptive capacity, and its imbalance leads to pathological changes, damage to molecular and cellular structures, carcinogenesis, and death.

It is well known that one of the key aspects that attracts the attention of scientists and medical specialists is the hormonal function of the gonads and its impact on the aging process (Bets, 2013; Bulgakova & Romanchuk, 2020; Goncharov & Katzya, 1998). The body's reproductive function is one of the most fundamental and highly significant biological functions, and its decline is one of the manifestations of natural aging in humans and animals (Anisimov, 2008; Svendsen & Schultz, 2008). The activity of the reproductive system is directly related to age, and the intensity of sex hormone production largely determines a person's biological age (Bulgakova & Romanchuk, 2020; Kulikov & Arkhipova, 2021; Medzinovskaya et al., 2018).

Despite a significant number of studies devoted to individual aspects of aging, the available literature lacks data obtained on the basis of complex biochemical, hormonal, and cellular hematological parameters in centenarians and their immediate relatives (Gavrilov et al., 2020; Kim et al., 2017; Kuznika et al., 2020; Pal'tsev et al., 2009; Hammad, 2017). Similar studies conducted on populations living in various regions of Azerbaijan are particularly limited (Gashimova et al., 2019; Kadimova, 2011; Karamova et al., 2024).

Aim of the Study. Based on the above, this study is dedicated to a comprehensive assessment of biochemical, hormonal, and cellular hematological parameters in centenarians and their immediate family members. Specifically, an attempt was made to determine the informative value of certain biochemical parameters, particularly lipid peroxidation and antioxidant activity (LPO and AOA), reflecting physiological aging processes. Levels of the sex hormones progesterone and dehydroepiandrosterone (DHEA) were also studied in centenarians and their immediate family members. Serum C-reactive protein (CRP) levels, widely used in clinical and experimental gerontology as an indicator of chronic low-grade inflammation associated with aging, were also studied.

Research materials and methods. The study was conducted in the Goychay region of Azerbaijan. After determining the age of centenarians living in these regions through verification (clarification of family history, survey of historical processes specific to these regions), they were registered. All individuals classified as centenarians were registered.

The subjects were divided into three groups: Group I consisted of generally healthy men and women aged 45-50 years with no centenarians among their immediate ancestors (a total of 31 individuals); Group II consisted of elderly men and women aged 60-80 years (a total of 29 individuals); and Group III consisted of the centenarians themselves—19 individuals aged 90 years and older, including 11 women and 8 men. Characterization and comparison of the groups was based on the gender and age of the subjects.

Exclusion criteria for the study included individuals with a history of cancer, cardiovascular disease, stroke or neurological disorders, liver disease, kidney disease, gout, thyroid disease, or hormonal imbalances. Each subject completed a voluntary informed consent form to participate in the study, which explained the nature and procedure of the study, potential inconveniences and risks, and consented to the processing of personal data, taking into account the principle of confidentiality (access only to the research team and presentation of data in a general dataset). All experiments were conducted in accordance with the principles of the Declaration of Helsinki (Finland, 1964) and after review by the Ethics Committee of the Abdulla Karayev Institute of Physiology, Ministry of Science and Education of the Republic of Azerbaijan (Protocol No. 1 dated December 2, 2022).

Venous blood with the addition of heparin and EDTA anticoagulants served as the material for the study. Venous blood was collected in the morning on an empty stomach between 8:00 and 9:00 AM. Non-hemolyzed plasma, obtained no later than 2 hours after blood collection by centrifugation for 10 minutes at 3000 rpm, was used for biochemical analysis. LPO intensity was assessed by the content of primary hydroperoxides (HP) and the secondary product malondialdehyde (MDA), which was determined using the method of Asakawa T. and Matsushita S. (1980). Catalase activity in our experiments was determined using the method of Bergmeyer H.U. SOD enzymatic activity was determined using the method of Beauchamp C. and Fridovich J.

Enzyme-linked immunosorbent assay (ELISA) was used to determine serum levels of the sex hormones progesterone and dehydroepiandrosterone (DHEA) using hormonal enzyme-linked immunosorbent assay kits from CLIA/Roche Diagnostics (Switzerland). Serum C-reactive protein levels were determined using an immunoassay based on the specific binding of CRP to antibodies to it. The experimental data were analyzed using the analysis of variation statistics using the parametric Student's t-test and the nonparametric Wilcoxon (Mann-Whitney) U-test. Statistical processing was performed using Microsoft Excel (Office 2010).

Methods

When studying the GP and MDA levels in Group I individuals (individuals from families without a history of longevity), the highest levels of lipid peroxidation products were observed. Thus, the hydroperoxide content was 1.54±0.06 relative units, and the MDA concentration was 3.70±1.75 nmol/mg protein, indicating pronounced lipid peroxidation activity.

Table 1

Dynamics of levels of primary – hydroperoxides (HP) and secondary – malondialdehyde (MDA) – lipid peroxidation products in centenarians and their close relatives (M±m)

Indicators Study groups	Hydroperoxides (HP), rel. Units	Malondialdehyde (MDA), nmol/mg protein
Group I - Representatives of families where there are no cases of longevity	1,54±0,06	3,70 ± 1,75
Group II - Descendants of long-livers	1,43±0,23*	3,13 ± 0,70*
Group III – long-livers (90 years and older)	1,27±0,51*	1,58 ± 0,61*

Note: * - $p < 0.05$.

However, it should be noted that in Group II—the offspring of centenarians—relatively low levels of both primary and secondary lipid peroxidation products were observed. Thus, the GP level averaged 1.43±0.23 relative units, and the MDA concentration was up to 3.13±0.70 nmol/mg protein, which was statistically significant compared to Group I ($p < 0.05$). These changes indicate a more balanced oxidative process in the offspring of centenarians (Table 1). When studying the free radical oxidation (FRO) status in the blood of centenarians, the following results were obtained: the hydroperoxide level was 1.27±0.51 relative units, and the MDA concentration was 1.58±0.61 nmol/mg protein. These values were statistically significant when compared with those in Groups I and II ($p < 0.05$) (Table 1).

Thus, a clear age-related and genealogical trend in the intensity of lipid peroxidation processes was revealed, characterized by a decrease in the level of oxidative damage to lipids in the descendants of centenarians, and especially in individuals who reached old age. In turn, it can be assumed that the decreased MDA content in centenarians compared to the control group may serve as a prognostic marker of high vitality and act as a biochemical criterion for longevity. Moreover, high lipid peroxidation levels in the control group can be considered a risk factor for the development of age-related diseases that hinder longevity.

These data may indicate the presence of hereditary and adaptive mechanisms aimed at limiting free radical oxidation during aging. To more fully characterize the pro- and antioxidant balance, the activity of key enzymes of the antioxidant system—catalase (CAT) and superoxide dismutase (SOD)—was studied. These enzymes constitute the body's first line of defense against reactive oxygen species. The study results are presented in Table 2.

Table 2

Activity of antioxidant enzymes - catalase (CAT) and superoxide dismutase (SOD) - in centenarians and their close relatives, (M±m)

Indicators Study groups	Catalase (CAT), U/mg protein	Superoxide dismutase (SOD), conventional units/mg protein
Representatives of families where cases of longevity have not been noted	47,5 ±6,2	192,0±17,3
Group II -Close relatives of centenarians	42,1±4,7**	100,07 ± 13,4**
Group III – centenarians (90 years and older)	27,3±0,19*	95,77 ± 9,5*

Note: *- $p < 0,05$, ** - $p < 0.01$.

The results obtained in this series of studies indicate that longevity is associated not with an enhancement but with an optimization of antioxidant processes, which is reflected in a decrease in the activity of enzymatic components of the antioxidant system. This suggests that during aging, the antioxidant system functions more balanced, maintaining the body's homeostasis with lower energy expenditure.

Studies in a group of representatives of families without a history of longevity revealed the highest levels of antioxidant enzyme activity, which is likely a compensatory response to increased free-radical processes. Catalase activity was 47.5 ± 6.2 U/mg protein, and superoxide dismutase activity was 192.0 ± 17.3 conventional units/mg protein (Table 2). Blood tests in the descendants of long-lived individuals (Group II) revealed statistically significant lower antioxidant enzyme activity levels compared to the control group ($p < 0.01$). Thus, CAT activity in this group averaged 42.1±4.7 U/mg

protein, and SOD activity averaged 100.07±13.4 conventional units/mg protein. A study of the blood serum of centenarians revealed lower antioxidant enzyme activity compared to other study groups ($p < 0.05$). Thus, catalase activity in the centenarian group averaged 27.3±0.19 U/mg protein, and superoxide dismutase activity averaged 95.77±9.5 conventional units/mg protein (Table 2).

Thus, a comprehensive analysis of lipid peroxidation parameters and antioxidant enzyme activity allows us to conclude that centenarians and their offspring develop a more stable balance between the formation of reactive oxygen species and their neutralization. The combined detection of reduced activity of enzymatic components of the antioxidant system against a background of low levels of lipid peroxidation products should be considered a characteristic biochemical marker of longevity, reflecting a state of balanced and optimized free radical homeostasis. The results of the study on the characteristics of endocrine status during longevity and hereditary predisposition to it are presented in Table 3. Analysis of the obtained data revealed that progesterone levels are characterized by significant variability depending on gender and study group.

Table 3
Sex hormone levels in centenarians of the Goychay district

Indicators	Progesterone (ng/ml)		Dehydroepiandrosterone (DHEA) (µg/dL)	
Study groups	Male	Female	Male	Female
Representatives of families where cases of longevity have not been noted	0,14±0,04	0,06±0,007	65,4±7,08	17,31±3,44
Group II – Close relatives of centenarians	0,08±0,02	0,15±0,02	112,4±9,9	46,2±0,33
Group III – centenarians (90 years and older)	0,07±0,02	0,18±0,03	63,7±8,2	19,1±1,6

In men from families without a history of longevity, the average progesterone level was 0.14±0.04 ng/ml, while in women from the same group, the average was 0.06±0.007 ng/ml. Thus, in families without a history of longevity, men had higher progesterone levels than women (Table 3). When examining progesterone levels in the group of centenarian offspring, the following results were obtained: in men, this value averaged 0.08±0.02 ng/ml, while in women it was 0.15±0.02 ng/ml (Table 3). According to our data, a similar pattern of changes was observed in the centenarian group. In men, progesterone levels averaged 0.07±0.02 ng/ml, lower than control values. At the same time, progesterone levels in centenarian women reached 0.18±0.03 ng/ml, which was higher than those in all female subgroups examined. DHEA levels revealed statistically significant differences between groups and genders. Blood tests in representatives of families without a history of longevity yielded the following results: the average DHEA concentration in men was 65.4±7.08 µg/dL, while in women it was 17.31±3.44 µg/dL (Table 3).

According to our data, in the group of centenarian descendants, men showed a significant increase in DHEA levels to 112.4±9.9 µg/dL, which is almost 1.7 times higher than in the control group. In women in this group (descendants of centenarians), DHEA concentrations also increased, reaching 46.2±0.33 µg/dL, which is 2.5 times higher than the same value in women in the control group. Studies in the centenarian group revealed decreased DHEA levels in both men and women. In centenarian men, this indicator was 63.7±8.2 µg/dL, while in centenarian women it was 19.1±1.6 µg/dL, approaching values typical for members of families without a history of longevity (Table 3).

In summary, the data obtained indicate that the descendants of centenarians had high DHEA levels, regardless of gender, which can be considered a possible biochemical marker of a hereditary

predisposition to longevity. At the same time, long-lived women are characterized by elevated progesterone levels, which may indicate the role of this hormone in adaptation mechanisms and maintaining homeostasis in old age and old age. These changes in hormonal profiles confirm the involvement of endocrine mechanisms in the development of longevity and suggest this area as a promising area for further scientific research. As shown in Table 4, the average CRP level in the control group, which included members of families with no history of longevity, was 6.48±1.08 mg/L. This indicator was the highest among all the groups examined. When examining CRP levels in Group II, which included close relatives of centenarians, statistically significant low levels of this indicator were found. In this group, the range was between 3.9 and 8.5 mg/L, with an average of 5.35±0.4.

Table 4

CRP Level as an Indicator of Chronic Inflammation in Centenarians

Indicators Study groups	C-reactive protein, mg/L
Group I - control (Representatives of families where cases of longevity have not been noted)	6,48±1,08
Group II - Close relatives of long-livers	5,35±0,4
Group III – long-livers (90 years and older)	5,56±0,6

Based on our data, it can be suggested that the CRP concentration in this group may indicate the presence of certain hereditary or familial factors that contribute to the development of a more favorable anti-inflammatory profile even before reaching old age.

The results of studies conducted in a group of centenarians (individuals aged 90 years and older) showed that the average CRP value ranged from 0.5 to 8.3 mg/L, averaging 5.56 ± 0.6 mg/L and lower than control values. Thus, the study found that centenarians and their close relatives had lower CRP levels compared to members of families without a history of longevity. This indicates a reduced severity of systemic inflammation in these groups. In turn, relatively low inflammatory activity can be considered an important component of the biological mechanisms of longevity, which is consistent with current understanding of the role of inflammation in aging. The observed C-reactive protein levels in centenarians and their relatives suggest that a favorable anti-inflammatory profile is formed through a combination of hereditary and familial environmental influences and is associated with longevity.

Results and discussion

The results of this study indicate that delayed aging and longevity are due to the development of a specific set of biological characteristics reflecting the optimal functioning of the body's regulatory systems. Centenarians and their immediate relatives exhibited a more favorable balance of pro- and antioxidant processes, characterized by reduced lipid peroxidation and balanced activity of antioxidant enzymes. These changes indicate not hyperactivation of defense mechanisms, but their efficient and functionally effective regulation.

Hormonal status characteristics, in particular variability in progesterone and dehydroepiandrosterone levels, confirm the involvement of endocrine mechanisms in maintaining the body's adaptive capacity and metabolic homeostasis during aging. Furthermore, reduced chronic inflammation, reflected by lower C-reactive protein concentrations, can be considered a key factor associated with longevity.

Taken together, the obtained data allow us to conclude that longevity is formed through the interaction of hereditary and adaptive regulatory mechanisms that ensure the stability of the body's internal environment in the face of age-related changes. A comprehensive analysis of biochemical, hormonal, and inflammatory parameters confirms the feasibility of their use as informative markers of delayed aging and identifies prospects for further research in the field of the molecular and physiological foundations of healthy human aging.

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Application of Machine Learning Algorithms in Disaster Risk Forecasting

Mir Ramin Yunusov[1*], Yalchin Zeynalov[2], Ibrahim Mazanov[3], Gafur Huseynov[3]

Abstract. *The escalating cascade of natural and anthropogenic hazards, exacerbated by global climate change and intricate industrial infrastructures, requires a fundamental reassessment of mathematical-analytical models in emergency response. This research mainly aims to comparatively evaluate of linear and non-linear mathematical equations that depict the spatio-temporal propagation dynamics of disaster risks. The analytical framework applies dynamic systems theory, ordinary and partial differential equations, bifurcation analysis and the mathematical modeling of cascade effects. Analytical practicalities and scenario simulations indicate that in cases restricted occurrences — including floods or minor landslides — linear autoregressive models and simple differential equations deliver reasonably precise and quick risk assessments. Conversely, in scenarios of swiftly developing, complicated disasters involving critical infrastructure failures, linear models demonstrate significant limitations. Modeling such asymmetric risks, disaster "tipping points," and exponential spatio-temporal propagation demands the application of reaction-diffusion equations and coupled non-linear systems. The results scientifically prove the boundaries of linear models in capturing real-world dynamics and validate the clear superiority of non-linear approaches in complex disaster scenarios.*

Keywords: *machine learning, cascade effects, non-linear dynamics, mathematical modeling, disaster risk, differential equations, tipping points, crisis management*

[1]Institute of Mathematics of the Ministry of Science and Education of the Republic of Azerbaijan, PhD Student, Baku Engineering University, Baku, Azerbaijan
[2]Baku Engineering University, Baku, Azerbaijan
[3]Azerbaijan Sports Academy, Baku, Azerbaijan
[*]Corresponding author. E-mail: myunusov@beu.edu.az
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Fəlakət risklərinin proqnozlaşdırılmasında maşın öyrənməsi alqoritmlərinin tətbiqi

Mir Ramin Yunusov[1*], Yalçın Zeynalov[2], İbrahim Mazanov[3], Qafur Hüseynov[3]

Xülasə. *Qlobal iqlim dəyişikliyi və mürəkkəb sənaye infrastrukturları tərəfindən daha da kəskinləşən təbii və antropogen təhlükələrin artan kaskadı fövqəladə hallara reaksiya zamanı riyazi-analitik modellərin əsaslı şəkildə yenidən qiymətləndirilməsini tələb edir. Bu tədqiqatın əsas məqsədi fəlakət risklərinin məkan-zaman yayılma dinamikasını təsvir edən xətti və qeyri-xətti riyazi tənlikləri müqayisəli şəkildə qiymətləndirməkdir. Analitik çərçivə dinamik sistemlər nəzəriyyəsini, adi və xüsusi törəməli diferensial tənlikləri, bifurkasiya analizini və kaskad effektlərinin riyazi modelləşdirilməsini tətbiq edir. Analitik praktikalar və ssenari simulyasiyaları göstərir ki, məhdud hadisələr (məsələn, daşqınlar və ya kiçik torpaq sürüşmələri) hallarında xətti avtoreqressiv modellər və sadə diferensial tənliklər kifayət qədər dəqiq və sürətli risk qiymətləndirmələri təqdim edir. Əksinə, kritik infrastrukturun sıradan çıxması ilə müşayiət olunan sürətlə inkişaf edən, mürəkkəb fəlakət ssenarilərində xətti modellər əhəmiyyətli məhdudiyyətlər nümayiş etdirir. Belə asimmetrik risklərin, fəlakətlərin "dönüş nöqtələrinin" (tipping points) və eksponensial məkan-zaman yayılmasının modelləşdirilməsi reaksiya-diffuziya tənliklərinin və əlaqəli qeyri-xətti sistemlərin tətbiqini tələb edir. Nəticələr real dünya dinamikasını əks etdirməkdə xətti modellərin sərhədlərini elmi cəhətdən sübut edir və mürəkkəb fəlakət ssenarilərində qeyri-xətti yanaşmaların aşkar üstünlüyünü təsdiqləyir.*

Açar sözlər: *maşın öyrənməsi, kaskad effektləri, qeyri-xətti dinamika, riyazi modelləşdirmə, fəlakət riski, diferensial tənliklər, dönüş nöqtələri, böhran vəziyyətlərinin idarə edilməsi*

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[1]Azərbaycan Respublikası Elm və Təhsil Nazirliyinin Riyaziyyat İnstitutu, doktorant, Bakı Mühəndislik Universiteti, Bakı, Azərbaycan
[2]Bakı Mühəndislik Universiteti, Bakı, Azərbaycan
[3]Azərbaycan İdman Akademiyası, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: myunusov@beu.edu.az
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Introduction

In contemporary times, as a result of global climate change, fast-paced urban expansion and the increasing complexity of industrial infrastructure, the frequency and scale of natural and anthropogenic emergencies have surged significantly. Specifically, wildfires, floods, seismic activities, and subsequent industrial accidents are transcending localized incidents, developing into cascade crises that present critical dangers to global socio-economic systems. Managing these multifaceted dangers, predicting vulnerabilities and reducing losses require the implementation of more exact and responsive mathematical-analytical models in decision-making processes.

Conventionally, disaster risk management and forecasting have been based on linear approaches, presuming that events occur in isolation and in unchanging environments. Linear mathematical models assume that the increase in risk correlates directly with corresponding factors, showing some level of utility in analyzing isolated incidents with restricted reach. Nevertheless, as the impact area of disasters expands, especially in multifaceted crises accompanied by the failure of critical infrastructure, linear dynamics fall short of reflecting reality. The mutual reliance between natural

and technological systems causes a minor triggering event to lead to unforeseen, highly unbalanced and exponentially growing consequences.

To overcome these limitations, contemporary academic studies has increasingly adopted non-linear differential equations that integrate principles from mathematical physics, dynamical systems, and chaos theory. The non-linear mathematical apparatus essentially enables for the modeling of disaster "tipping points" in emergency situations, the speeding up processes of cascade effects and the asymmetric spatio-temporal propagation patterns (Helbing & Ammoser, 2023; Sullivan, 2021). Expressing the interaction processes of risks through a system of differential equations provides a fundamental basis for developing optimal strategies to mitigate initial and subsequent catastrophes (Vinay et al., 2020).

Methods

This study presents a comprehensive review of the application of Machine Learning (ML) algorithms in disaster risk forecasting. It examines the limitations of conventional forecasting methods, outlines the theoretical underpinnings of ML, and surveys advanced global practices for modeling disaster risks. Natural hazards—including hydrological events such as floods, geological phenomena like earthquakes, forest fires, and urban fires—continue to pose significant and growing threats to both economic and social stability worldwide. Timely and accurate forecasting, which underpins contemporary risk management strategies, is essential for minimizing casualties and economic losses through the effective operation of Early Warning Systems. Traditional forecasting approaches predominantly rely on deterministic models or relatively simple statistical methods. However, disasters are inherently multifactorial, non-linear, and dynamically complex. Conventional forecasting methods can be broadly categorized into two main types:

1. Time Series Models: These statistics-based models dominated emergency forecasting, including flood prediction, from 1993 to 2010. They require relatively low computational resources and are suitable for simple forecasting scenarios. Nevertheless, their capacity to capture the non-linear dynamics of complex ecological and hydrological systems is limited.

2. Physics-based Models: Grounded in physical laws, these models can accurately represent characteristics of the Earth's crust, water basins, or other environmental systems. However, they demand extensive parameterization and high computational resources, making adaptation to local conditions challenging.

Since 2011, advances in computational power have facilitated the widespread adoption of Machine Learning models—particularly Artificial Neural Networks—for disaster forecasting. ML models, characterized by non-linear time series capabilities, offer superior accuracy and reliability compared to traditional methods. Their deployment marks a paradigm shift in disaster management, transitioning from rule-based approaches to data-driven predictive modeling. A key advantage of ML models lies in their ability to uncover complex relationships within large, heterogeneous datasets. This capability enhances the precision and reliability of forecasts within Early Warning Systems, while also extending the lead time available for preventive action (Petros et al., 2025). A comparative analysis of traditional and ML-based forecasting models is provided in the literature (Vinay et al., 2020; Manaswi et al., 2025).

Table 1
Comparison of Traditional and Machine Learning Methods

Feature	Traditional methods	Machine Learning
Model basis	Physical laws, differential equations, linear dependencies	Data-driven, nonlinear relationships, ability to process large-scale data
Model scale	Low/medium-volume linear data	Efficient processing of multidimensional, large-scale data; improved predictive capability with increasing data volume
Economic loss assessment	High potential for overestimation of losses	Flexibility, real-time analysis of impacts using social media data
Limitations	High computational cost, reduced nonlinear accuracy under dynamic changes, time lag	Sensitivity to data quality, difficulty in interpretability, lower stability under extreme conditions

Achieving accuracy in time series forecasting fundamentally relies on the precise identification and modeling of the intrinsic structures within the data. Any robust time series model must incorporate four core components: Trend, representing long-term upward or downward movements; Seasonality, capturing predictable patterns recurring at fixed intervals; cyclical components, reflecting non-seasonal fluctuations driven by broader economic or business conditions and irregular components, denoting random, unexplainable variations. Classical econometric models, such as the AutoRegressive Integrated Moving Average family, are effective for short-term forecasting and modeling linear dependencies but often fall short in capturing the intricate non-linear dynamics inherent in complex domains like finance, environmental systems, and industrial datasets.

The emergence of Machine Learning and Deep Learning architectures has provided the computational capabilities required to model such non-linear complexities. These models exhibit marked advantages over traditional statistical approaches, particularly when managing large, heterogeneous feature sets and learning long-term temporal dependencies embedded in sequential data (Lakshmi et al., 2020). Amid the increasing frequency and complexity of natural disasters, the field of Disaster Risk Reduction is experiencing transformative changes. The integration of ML algorithms introduces innovative methodologies that combine simulation and optimization frameworks to address dynamic, uncertain, and highly complex disaster scenarios. These approaches not only enhance predictive accuracy but also yield valuable insights for improving the resilience and effectiveness of emergency response strategies (Huseynov, 2023).

The application of ML spans both physical and social dimensions of disaster management. For example, during Hurricane Harvey, rescue requests were analyzed using ML techniques. By leveraging social media data, researchers can assess the geographical distribution, frequency, and impact of disasters, thereby enabling policymakers to make informed, real-time decisions. Furthermore, in urban planning, ML utilizes historical data to predict urban resilience characteristics, contributing to the development of long-term risk management strategies.

Despite significant advancements in ML applications, several fundamental data-related challenges persist in natural disaster prediction. Key obstacles include the scarcity of real-time open-source data, the imbalance of datasets critical for effective model training, and the difficulties associated with interdisciplinary collaboration among experts from diverse domains. Given that disasters are inherently rare events, ML models face a scientifically significant challenge: they tend to adapt to the majority class, potentially overlooking the minority class. Addressing this issue requires specialized mathematical and algorithmic strategies, such as data balancing techniques or class-weight adjustments during model training. Additionally, the use of specialized evaluation metrics, such as

F1-score or PR-AUC, is essential for accurately assessing model performance in predicting these rare but critical events.

Despite the generalized analytical strength of Machine Learning algorithms, empirical research consistently indicates that no single forecasting method exhibits universal superiority. Optimal performance is highly context-dependent, relying on the specific characteristics and data type of the analyzed time series. For instance, in studies on disaster risk forecasting, particularly earthquake magnitude prediction, Deep Learning models such as Long Short-Term Memory networks demonstrated higher accuracy and effectiveness compared to traditional methods like ARIMA. This underscores the capability of advanced ML architectures to model the non-linear and complex nature of natural hazard data, which often exhibits high non-linearity and extensive temporal dependencies.

Further research comparing LSTM and ARIMA in general disaster-related time series emphasizes this duality. ARIMA may achieve lower error values in monthly or weekly forecasts, reflecting its stability in capturing dominant seasonal or long-term linear patterns. In contrast, LSTM outperforms ARIMA in daily rolling predictions. This distinction highlights that model selection is not simply a choice between linear and non-linear approaches; it depends on the dominant dependency structure and the required forecasting horizon. When a series exhibits strong short-term autocorrelation and limited external influence, linear models like ARIMA may provide more reliable results. Conversely, in scenarios characterized by high noise, volatile trends, and complex feature interactions—typical in multi-variable disaster data—ML ensembles and Deep Learning architectures, such as XGBoost or LSTM, offer distinct advantages.

For ML algorithms to process time series data effectively, the sequential structure must be transformed into a format suitable for supervised regression tasks—a critical step known as Feature Engineering, which largely determines the predictive ceiling of the model.

Stationarity—the constancy of mean, variance, and autocorrelation over time—is vital for model stability and generalization. Techniques such as differencing, which calculates the difference between consecutive observations, are employed to stabilize the data. While univariate models like ARIMA can be trained on undifferenced data, multivariate ML models typically require differenced versions of the target variable and external regressors as input features, ensuring stationarity in the feature space and enhancing model robustness.

Since ML regressors do not inherently capture temporal dependencies, these relationships must be encoded explicitly:

- **Lags**: Past values of the target variable and external regressors are transformed into independent predictor features, effectively integrating the autoregressive component of classical models into the ML framework.
- **Rolling Window Statistics**: Statistical summaries computed over defined rolling windows capture local trends, volatility, and short-term dynamics. These features are particularly useful for high-frequency or noisy data, such as financial or disaster-related series, where short-term variations contain substantial predictive information.

Machine Learning Architectures for Disaster Risk Forecasting require broad and diverse datasets to ensure accurate predictions (Kim and Lee, 2018). Relevant data can be grouped into the following categories:

- **Disaster Classification Data** – type, location, time, and scale of damage;
- **Geographic Information System (GIS) Data** – topography, soil type, forest cover, relief;
- **Meteorological Data** – precipitation, temperature, wind speed;
- **Socio-economic Data** – population density, infrastructure types.

ML applications in disaster risk forecasting are generally divided into two main categories: **Classification Algorithms** and **Regression Models.**
Classification Algorithms determine whether a disaster is likely to occur (Yes/No) or categorize its risk level (low, medium, high). This approach is essential for timely decision-making in risk grading and early warning systems to prevent incidents.
Regression Models provide quantitative predictions, such as the intensity of the event, potential damages, or the time until occurrence. These predictions are critical for resource allocation, response planning, and operational management (Table 2).

Table 2
Categories of Machine Learning Algorithms

Categories of ML algorithms	Purpose in the field of disasters	Sample algorithms
Classification	To predict the probability of an event occurrence (yes/no) or the level of risk (low/medium/high)	logistic regression, random forest, gradient boosting
Regression	To predict the intensity of the event, the amount of damage, or the time remaining until the event	linear regression, neural networks, support vector regression

The classification and regression of disaster risks have seen extensive application through both traditional and ensemble algorithms. Due to their higher interpretability compared to Deep Learning models, these algorithms remain vital in Early Warning Systems, supporting timely decision-making and risk mitigation.

In numerous disaster prediction studies, foundational algorithms such as Logistic Regression and Support Vector Machines have been widely employed (Vasileios et al., 2022). LR is particularly effective for linear classification tasks and can deliver optimal results in specific applications, such as text classification. SVM, on the other hand, excels at modeling non-linear classification boundaries and has demonstrated robust performance across complex datasets. Contemporary research has even explored quantum-enhanced versions of SVM, such as QSVC_ML, to further improve predictive accuracy and computational efficiency.

Support Vector Regression, a non-parametric regression technique derived from SVM, effectively handles non-linear regression problems by utilizing kernel functions, such as the Radial Basis Function, to implicitly map data into higher-dimensional feature spaces. SVR offers several notable advantages:
- **Resistance to Overfitting**: Unlike complex Artificial Neural Networks, which may converge to local optima, SVR tends to find a global optimal solution, reducing susceptibility to overfitting and ensuring more robust predictions.
- **ϵ-Insensitive Loss Function**: The core mechanism of SVR is the ϵ-insensitive loss function, which introduces the hyperparameter ϵ to define a margin of acceptable error. Prediction errors within the ϵ threshold are considered to incur zero loss, providing a controlled balance between the desired smoothness of the regression function f(x)f(x)f(x) and tolerance for deviations exceeding ϵ.

The formal description of the linear ϵ-insensitive loss function is provided as follows:

$$L_{\in}\begin{cases}0 & if\ |y-f(x)| \leq \in \\ |y-f(x)|-\in & otherwise\end{cases} \quad (1)$$

Ensemble Learning Methods: Superiority and Robustness. Ensemble learning methods enhance predictive performance and robustness by combining the outputs of multiple individual models (weak

learners). These methods are particularly effective in tasks characterized by high uncertainty, such as disaster risk classification, where they consistently provide more stable, accurate, and reliable results compared to single-model approaches.

Random Forest (RF). The Random Forest (RF) algorithm employs a bagging strategy, constructing multiple decision trees, each trained independently on randomly sampled subsets of the training data. This independence underpins RF's key advantages: parallelizable training and execution, strong resistance to overfitting, and high efficiency on large-scale datasets. RF is therefore widely adopted in disaster risk forecasting for both classification and regression tasks (Nti et al., 2022).

Gradient Boosting (GBT). Gradient Boosting relies on the boosting principle, where decision trees are built sequentially, with each new tree trained to correct the residual errors of its predecessors. Optimized implementations such as XGBoost and LightGBM have substantially enhanced the computational speed and predictive performance of GBT. While GBT often surpasses RF in prediction accuracy—especially on smaller, cleaner datasets—it is particularly effective at capturing complex, non-linear patterns within high-dimensional data, making it a preferred choice for advanced disaster risk modeling (Murphy & Smith, 2023).

Table 3
Characteristics of Random Forest and Gradient Boosting Algorithms

Random Forest (RF)	Gradient Boosting (GBT)
Enables parallel training and execution, ideal for real-time applications	Sequential structure; improved with distributed computing
More robust to noisy data, lower risk of overfitting	Often achieves higher accuracy in clean datasets
Provides stable and reliable performance	Better at capturing complex nonlinear relationships

Regression Models: Predicting Quantitative Characteristics of Disasters. While classification models focus on predicting the occurrence or category of an event, regression models are indispensable for estimating the quantitative characteristics of disasters. These models forecast continuous variables such as the magnitude of damage, financial losses, or resource requirements, providing essential information for emergency planning and response allocation.

Deep Learning Architectures and Spatio-Temporal Dependency Modeling. Large-scale spatial and temporal datasets, including satellite imagery and high-resolution meteorological time series, present significant challenges for traditional Machine Learning models. Deep Learning (DL) architectures excel in capturing these complex dependencies due to their ability to process high-dimensional, sequential, and interdependent data structures.

Time-Series Models: RNN and LSTM. Recurrent Neural Networks provide a foundation for sequential data processing. However, Long Short-Term Memory networks overcome the vanishing gradient problem of conventional RNNs and efficiently capture long-term dependencies. By leveraging specialized gating mechanisms—forget, input, and output gates—LSTMs effectively model seasonality and trends in climate, seismic, and hydrological time-series datasets.

Hybrid CNN–LSTM Frameworks: Spatio-Temporal Forecasting. Forecasting disasters such as floods, hurricanes, or extreme rainfall events often requires simultaneous analysis of spatial and temporal patterns. Hybrid Convolutional Neural Network–LSTM architectures are particularly suitable for such tasks, integrating spatial feature extraction with temporal sequence modeling to improve prediction accuracy (Wang et al., 2024).

Evaluation Metrics in Disaster Forecasting. In disaster prediction scenarios, it is crucial to balance **Precision** and **Recall**:

- **Precision** measures the proportion of predicted disaster events that are actual disasters. High precision minimizes false alarms, reducing unnecessary evacuation costs and resource waste.
- **Recall** measures the proportion of true disasters correctly identified. Recall is critical in emergency management as it directly mitigates the risk of missed events, which could result in loss of life.
- **F1 Score** represents the harmonic mean of precision and recall, providing a single, reliable metric that accounts for both false positives and false negatives in imbalanced datasets.

Importance of Python Programming and Software Foundations. Python has become the standard programming language for Machine Learning and disaster risk forecasting. Its extensive libraries, straightforward syntax, and robust support for scientific computing make it ideal for building, testing, and deploying predictive models in both research and operational environments.

Table 4
Main Python libraries for data forecasting

Library	Role	Application in disaster modeling
Pandas/Numpy	Data manipulation and numerical operations	Loading, cleaning, and extracting features (year, month, day) from time-series data (seismic, climate)
Scikit-learn	Classical ML, preprocessing, model selection	Training models such as RandomForestClassifier and SVM; data normalization using StandardScaler
TensorFlow / PyTorch	Deep learning architectures	Building CNN-LSTM and Transformer models for spatio-temporal prediction of large satellite imagery
Imbalanced-learn	Handling class imbalance	Synthesizing minority classes using SMOTE (Synthetic Minority Oversampling Technique)

Real-Time Data Processing and Python Ecosystem in Disaster Management. Effective disaster management demands the rapid collection, processing, and analysis of real-time open-source data. Python's comprehensive ecosystem—including libraries such as Pandas, Scikit-learn, and **TensorFlow**—enables seamless data loading, preprocessing, and analysis. This standardized workflow ensures reproducibility of research findings and promotes efficient interdisciplinary collaboration between domain experts, emergency managers, and Machine Learning engineers (Sebastian et al., 2020).

Forecasting Seismic Disasters. Machine Learning applications in seismology are primarily oriented toward pre-event forecasting and post-seismic classification. Algorithms such as K-Nearest Neighbors and Support Vector Machines, along with Deep Learning architectures—including Artificial Neural Networks, Multilayer Perceptron, Convolutional Neural Networks, Recurrent Neural Networks, and Long Short-Term Memory—have been extensively employed. For time-dependent phenomena, such as radon gas measurements and ionospheric electron anomalies, LSTM, ARIMA, SVM, and ANN have been applied, with LSTM often demonstrating superior predictive performance.

Seismological forecasting focuses on early warning systems (detecting P-waves immediately after an event) and hazard assessment (long-term probability mapping). While precise prediction of earthquake timing remains scientifically elusive due to the complex, non-linear nature of seismic features, ML excels in post-seismic analysis, enabling rapid classification of structural damage and mapping of aftershock probabilities using real-time sensor data and aerial imagery processed by CNN.

A key limitation in earthquake forecasting is the inability to predict the exact event timing, stemming from incomplete knowledge of all causative factors. Early Earthquake Warning Systems provide rapid alerts post-event rather than advance predictions. Consequently, ML demonstrates its greatest utility in post-seismic assessments, where rapid classification over structured data is essential.

Forecasting Hydrological Disasters

Flood prediction relies on temporal and spatio-temporal data, including precipitation, water levels, and flow velocity (Beroza & Mousavi, 2021; Kong et al., 2021). RNNs and their variants dominate hydrological forecasting (Kim & Lee, 2018; Alizamir et al., 2020).

1. LSTM (Long Short-Term Memory) – Used for modeling water level and river flow relationships, integrating forecasts into GIS software to visualize flood-prone areas.
2. ConvLSTM (Convolutional LSTM) – Enhances spatio-temporal forecasting by first extracting spatial patterns via convolutional layers and then capturing long-term temporal dependencies with LSTM layers (Caisu & Hailiang, 2023; Zhang et al., 2023).

Research demonstrates high predictive accuracy: ConvLSTM achieves $R^2 \approx 0.96$ and Nash–Sutcliffe Efficiency (NSE) ≈0.95, while LSTM shows similar performance in water level simulations. These high-accuracy forecasts enable the creation of flood risk maps, providing critical tools for decision-making and resource allocation. Comparative studies consistently highlight DL models' superiority over ARIMA and traditional statistical methods for capturing long-term meteorological-hydrological dependencies.

Forecasting Wildfires. ML and DL methods significantly enhance the prediction of forest fire spread. Techniques such as CNN, Convolutional Recurrent Networks, Transformers, Reinforcement Learning, and Graph Neural Networks are widely applied. CRNs and time-series models effectively capture sequential and spatio-temporal fire behavior. For example, CNN combined with ASPP identifies general and detailed fire spread patterns (Chen et al., 2022; Jain et al., 2020).

High-dimensional data processing and feature extraction give DL models a clear advantage over traditional methods. In studies using the California wildfire dataset, patch-based forecasting achieved an F1-score of 96%. However, the complexity of DL models introduces a "black-box" problem, necessitating Explainable AI solutions. Techniques like Grad-CAM and SHAP improve interpretability, highlighting key factors influencing fire propagation. Real-time forecasting demands lightweight models with low computational cost, particularly in remote areas. Data quality remains a challenge: sparse or missing inputs can bias models, reducing generalizability when applied across different regions. Ensemble methods such as XGBoost have been applied for urban fire severity prediction. Using structured building data, XGBoost achieved 82.7% accuracy, enabling fire departments to anticipate fire intensification and allocate resources efficiently via GIS. Unlike forest fire DL models, urban fire forecasting emphasizes rapid, high-accuracy classification. Ensemble methods are particularly suited to urban environments due to their ability to handle structured, heterogeneous data and deliver fast predictions. This complements DL models for wildfires and floods, which focus on continuous spatio-temporal event forecasting.

Results and Discussion

This thorough analysis clearly shows that Machine Learning and Deep Learning methodologies provide significant benefits compared to traditional deterministic and statistical approaches in the field of disaster risk prediction. Moving towards, data-driven architectures is critical for handling the enormous, heterogeneous datasets generated by modern sensor networks and satellite observations. In contrast to conventional methods, which often struggle to represent highly non-linear

environmental dynamics, modern computational techniques—such as ensemble techniques and deep neural networks—are highly effective at identifying complex spatio-temporal dependencies. As demonstrated in multiple fields, including seismic hazard assessment, hydrological flood modeling, and wildfire spread prediction, these algorithms substantially improve prediction reliability and early warning periods.

As a result, the implementation of these highly developed predictive frameworks equips policymakers and emergency management agencies with highly accurate, region-specific data. This advancement in technology promotes a fundamental shift in perspective from traditional, reactive disaster response to highly proactive, anticipatory risk mitigation, in strict accordance with global initiatives like the Sendai Framework.

Despite these advancements, a number of significant hurdles persist to be addressed in future studies. The scientific community should focus on creating reliable algorithmic remedies for significant data imbalance—a common issue when predicting infrequent disaster occurrences. Additionally, optimizing the computational efficiency of these predictive systems for real-time deployment in resource-constrained areas is crucial. Finally, resolving the inherent "black-box" nature of deep learning through Explainable AI is strictly required to ensure model transparency, thus building trust among decision-makers and ensuring the reliability of automated Early Warning Systems.

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Development and Experimental Evaluation of a Frequency-Hopping-Based Control and Telemetry System for Unmanned Aerial Vehicles Under Radio-Electronic Warfare Conditions

Muxtar Azizullayev[1*], Rashad Nematzade[2], Gunel Rzayeva[3], Turkan Muradova[4], Nuray Azizullayeva[4]

Abstract: *This study examines a frequency hopping-based communication approach aimed at improving the reliability of unmanned aerial vehicle (UAV) telemetry systems under radio-electronic warfare conditions. Within the framework of the research, a flight controller based on the STM32 F405 microcontroller was designed in the EasyEDA environment, and two alternative telemetry communication configurations were implemented on the same hardware platform. In the first configuration, the NRF24L01 module was employed for communication in the 2.4 GHz band, whereas in the second configuration, the RFD868x module operating in the 868 MHz band was integrated and evaluated under identical test conditions. To enhance resistance against interference and channel blocking, a frequency hopping algorithm was developed and incorporated into the telemetry architecture. Experimental investigations were carried out at distances of 50 m, 100 m, 200 m, and 500 m in order to assess the communication performance of both configurations. During the tests, key transmission parameters, including RSSI, SNR, BER, latency, and Path Loss, were measured and interpreted together with the corresponding mathematical models. The results indicate that the proposed frequency hopping approach significantly increases telemetry channel resilience in the presence of radio-electronic interference. In addition, the comparative analysis confirms that communication stability depends not only on the hopping strategy itself, but also on the selected frequency band, telemetry module characteristics, and antenna configuration.*

Keywords: *unmanned aerial vehicle (UAV), telemetry system, frequency hopping, FHSS, radio-electronic warfare, electromagnetic interference, signal-to-noise ratio (SNR), received signal strength indicator (RSSI), bit error rate (BER), path loss, telemetry channel, communication reliability, flight controller, anti-jamming communication, wireless telemetry*

[1]Azerbaijan Technical University, PhD student, Baku, Azerbaijan
[2]Baku, Azerbaijan
[3]Institute of Scientific Research Aerospace Informatics of NASA, Baku, Azerbaijan
[4]Azerbaijan Technical University, bachelor, Baku, Azerbaijan
[*]Corresponding author. E-mail: mukhtar.azizullayev@aztu.edu.az
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Radioelektron mübarizə şəraitində pilotsuz uçuş aparatlarının idarə olunması və telemetrik məlumat ötürülməsi üçün tezlik sıçrayışlı sistemin işlənib hazırlanması və eksperimental sınaqları

Muxtar Əzizullayev[1*], Rəşad Nemətzadə[2], Günel Rzayeva[3], Türkan Muradova[4], Nuray Əzizullayeva[4]

Xülasə: *Bu tədqiqat radioelektron mübarizə şəraitində pilotsuz uçuş aparatlarının (PUA) telemetriya sistemlərinin etibarlılığının artırılmasına yönəlmiş tezlik sıçrayışına əsaslanan rabitə yanaşmasını araşdırır. Tədqiqat çərçivəsində EasyEDA mühitində STM32 F405 mikroidarəedicisi əsasında uçuş kontrolleri layihələndirilmiş və eyni aparat platformasında iki alternativ telemetriya rabitə konfiqurasiyası həyata keçirilmişdir. Birinci konfiqurasiyada 2,4 GHz diapazonunda rabitə üçün NRF24L01 modulu istifadə edilmiş, ikinci konfiqurasiyada isə 868 MHz diapazonunda fəaliyyət göstərən RFD868x modulu inteqrasiya olunmuş və eyni sınaq şərtləri altında qiymətləndirilmişdir. Müdaxilələrə və kanalın bloklanmasına qarşı dayanıqlığın artırılması məqsədilə tezlik sıçrayışı alqoritmi hazırlanmış və telemetriya arxitekturasına inteqrasiya edilmişdir. Hər iki konfiqurasiyanın rabitə göstəricilərini qiymətləndirmək üçün 50 m, 100 m, 200 m və 500 m məsafələrdə eksperimental tədqiqatlar aparılmışdır. Sınaqlar zamanı RSSI, SNR, BER, gecikmə (latency) və yol itkisi (Path Loss) kimi əsas ötürmə parametrləri ölçülmüş və müvafiq riyazi modellərlə birlikdə təhlil edilmişdir. Nəticələr göstərir ki, təklif olunan tezlik sıçrayışı yanaşması radioelektron müdaxilələrin mövcud olduğu şəraitdə telemetriya kanalının dayanıqlığını əhəmiyyətli dərəcədə artırır. Bundan əlavə, müqayisəli təhlil təsdiq edir ki, rabitənin sabitliyi yalnız tezlik sıçrayışı strategiyasından deyil, həm də seçilmiş tezlik diapazonundan, telemetriya modulunun xüsusiyyətlərindən və antenna konfiqurasiyasından asılıdır.*

Açar sözlər: *pilotsuz uçuş aparatı (PUA), telemetriya sistemi, tezlik sıçrayışı, FHSS, radioelektron mübarizə, elektromaqnit müdaxiləsi, siqnal-küy nisbəti (SNR), qəbul edilmiş siqnal gücü göstəricisi (RSSI), bit səhv əmsalı (BER), yol itkisi (Path Loss), telemetriya kanalı, rabitənin etibarlılığı, uçuş kontrolleri, müdaxiləyə davamlı rabitə, simsiz telemetriya*

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[1]Azərbaycan Texniki Universiteti, doktorant, Bakı, Azərbaycan
[2]Bakı, Azərbaycan
[3]MAKA-nın Elmi Tədqiqat Aerokosmik İnformatika İnstitutu, Bakı, Azərbaycan
[4]Azərbaycan Texniki Universiteti, bakalavr, Bakı, Azərbaycan
[*]Məsul müəllif. E-poçt: mukhtar.azizullayev@aztu.edu.az
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Introduction

In recent years, unmanned aerial vehicles (UAVs) have been widely used in military, civil, industrial, and monitoring applications due to their mobility, rapid deployment, and multifunctional capabilities. The operational efficiency of UAVs strongly depends on the reliability of telemetry and control links, which ensure real-time data exchange between the onboard system and the ground station. Under radio-electronic warfare (REW) conditions, these links may be degraded by signal attenuation, noise, and intentional electromagnetic interference, resulting in data loss, increased latency, and reduced signal quality (Azizullayev & Nematzade, 2025; Aghayev et al., 2025).

Similar reliability challenges are also observed in other unmanned platforms, including unmanned surface vehicles and intelligent autonomous systems, where communication resilience, situational awareness, and operational stability are critical for mission performance (Rustamov et al., 2025).

Fixed-frequency telemetry channels are particularly vulnerable to detection, suppression, and jamming in hostile electromagnetic environments. Frequency-Hopping Spread Spectrum (FHSS) is considered an effective anti-jamming method because it changes the carrier frequency according to a pseudo-random sequence and reduces the probability of continuous interference on a single channel (Rüstəmov et al., 2023; Rustamov et al., 2024). Telemetry reliability depends not only on the communication protocol, but also on operating frequency, antenna characteristics, and module design (Rustamov et al., 2025; Ghouz et al., 2020).

In this study, an FHSS-based telemetry approach is investigated using an STM32 F405-based flight controller designed in the EasyEDA environment. Two telemetry configurations are compared: NRF24L01 operating in the 2.4 GHz band and RFD868x operating in the 868 MHz band. Their performance is evaluated at distances of 50 m, 100 m, 200 m, and 500 m using RSSI, SNR, effective SNR, SINR, BER, latency, and path loss indicators. The scientific contribution of this paper is the integrated evaluation of an STM32 F405-based UAV telemetry architecture, FHSS-based communication, two telemetry modules operating in different frequency bands, antenna radiation characteristics, and mathematical channel models within a unified framework.

Recent studies show that UAV telemetry reliability is a key factor affecting mission continuity, flight safety, and operational stability under radio-electronic warfare conditions. Telemetry channels are mainly degraded by propagation loss, external noise, intentional interference, and jamming due to limited transmission power, compact antennas, and variable flight conditions (Azizullayev & Nematzade, 2025; Aghayev et al., 2025). Telemetry degradation is usually reflected in reduced received signal strength indicator (RSSI), signal-to-noise ratio (SNR), signal-to-interference-plus-noise ratio (SINR), and packet delivery ratio (PDR), while bit error rate (BER), packet loss ratio (PLR), path loss, and latency increase with distance and interference intensity. Therefore, these indicators are widely used to evaluate telemetry reliability under interference-affected conditions (Rustamov et al., 2025; Yang et al., 2025).

Fixed-frequency telemetry systems are vulnerable to detection, suppression, and channel blocking. FHSS is widely applied as an anti-jamming method because it changes the operating frequency according to a pseudo-random sequence and reduces the probability of continuous interference on a single carrier. However, its effectiveness depends on the selected frequency band, receiver sensitivity, antenna gain, transmission power, and module characteristics (Rüstəmov et al., 2023; Zidane et al., 2024).

The operating frequency band also affects telemetry reliability. NRF24L01 modules operating at 2.4 GHz are suitable for compact UAV platforms and short-range low-latency telemetry, but this band is more sensitive to path loss and interference. In contrast, sub-GHz systems such as RFD868x at 868 MHz generally provide lower path loss, better propagation stability, and stronger signal quality over longer distances (Azizullayev, 2025; Rustamov et al., 2024). Flight controller and antenna design are also important for reliable telemetry integration. STM32 F405-based controllers provide sufficient processing capability and interfaces such as UART, SPI, and I2C for integrating different telemetry modules. In addition, antenna gain, radiation pattern, and directional energy distribution directly affect RSSI, SNR, SINR, and link stability (Rustamov et al., 2025; Ghouz et al., 2020).

Despite existing studies on UAV telemetry and anti-jamming communication, many works focus on only one module, one frequency band, or one performance indicator. Therefore, this study evaluates NRF24L01 and RFD868x telemetry configurations on the same STM32 F405-based UAV flight

controller platform using FHSS-based communication, mathematical modeling, antenna radiation analysis, and comparative performance indicators.

Methods

This study evaluates the performance and reliability of UAV telemetry systems under radio-electronic warfare (REW) conditions. Since telemetry channels operate in dynamic electromagnetic environments, their quality was assessed using RSSI, SNR, SINR, BER, path loss, and latency, which are commonly applied to analyze wireless links affected by interference and signal degradation (Azizullayev & Nematzade, 2025; Rustamov et al., 2025). RSSI characterizes the received signal level, SNR reflects the ratio between useful signal and noise, SINR accounts for both noise and interference, BER indicates transmission error probability, path loss describes distance-dependent attenuation, and latency represents transmission delay (Heydərov & Əzizullayev, 2024). Under REW conditions, fixed-frequency telemetry channels are vulnerable to jamming; therefore, FHSS was applied to improve communication robustness by switching the carrier frequency according to a pseudo-random sequence (Rüstəmov et al., 2023; Zidane et al., 2024).

3.1. Proposed UAV System Architecture. The proposed telemetry system was implemented on an STM32 F405-based flight controller. Two telemetry configurations were evaluated under identical operating conditions: NRF24L01 in the 2.4 GHz band for short-range low-latency communication, and RFD868x in the 868 MHz band for more stable long-range telemetry transmission. This structure enables the comparative assessment of frequency band, module characteristics, and interference effects on UAV telemetry performance (Heydərov & Əzizullayev, 2024; Rustamov et al., 2025).

The system architecture is shown in the following diagram, illustrating the interaction between the flight controller, telemetry modules, antennas, and communication interfaces.

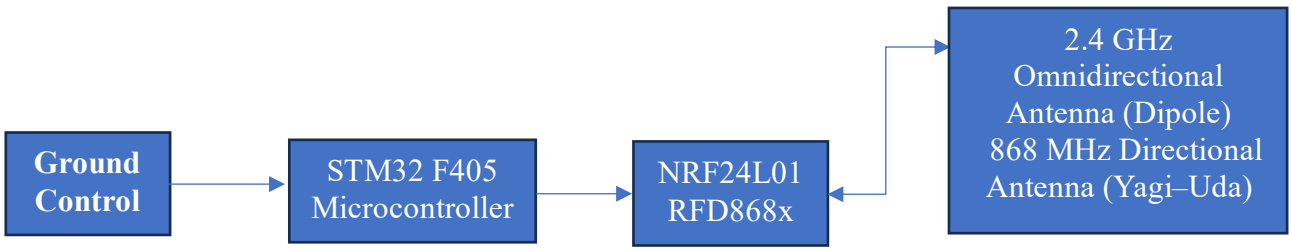
Ground Control
STM32 F405 Microcontroller
NRF24L01 RFD868x
2.4 GHz Omnidirectional Antenna (Dipole) 868 MHz Directional Antenna (Yagi–Uda)

Figure 1
Functional-structural block diagram of the transmitter section of the UAV telemetry system

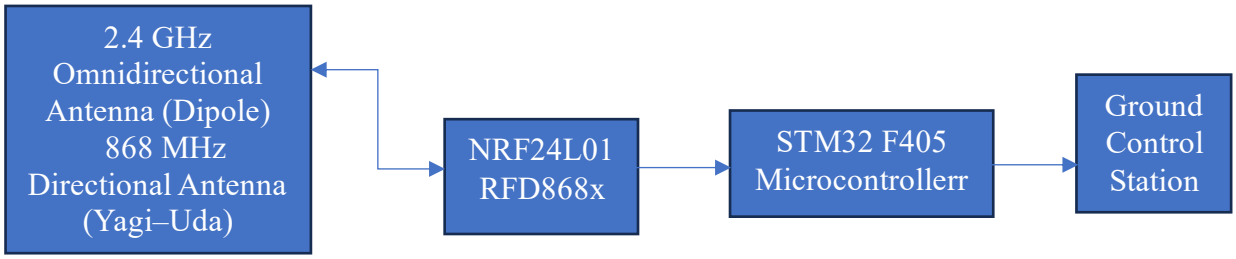
2.4 GHz Omnidirectional Antenna (Dipole) 868 MHz Directional Antenna (Yagi–Uda)
NRF24L01 RFD868x
STM32 F405 Microcontrollerr
Ground Control Station

Figure 2
Functional-structural block diagram of the receiver section of the UAV telemetry system

Figures 1 and 2 show the functional block diagrams of the transmitter and receiver sections of the UAV telemetry system and present its overall communication architecture. In this structure, the STM32 F405 microcontroller acts as the central control unit, processing sensor and control data and transmitting them to the NRF24L01 or RFD868x telemetry modules via UART and SPI interfaces.

The signal is then radiated through the antenna, received on the opposite side, demodulated by the telemetry module, and forwarded to the microcontroller for further processing. Data exchange is carried out through SPI, UART, and I2C protocols, while an FHSS-based frequency hopping mechanism is applied to improve resistance to interference. As a result, the proposed architecture enhances transmission reliability and communication stability under radio-electronic warfare conditions.

Flight Controller Architecture. In this study, the flight controller was designed in the EasyEDA environment. Its architecture includes the microcontroller core, power management unit, sensor interfaces, and communication ports for telemetry module integration. The microcontroller performs flight control, sensor data acquisition and processing, and telemetry packet generation, while UART and SPI interfaces support telemetry communication. Stable system operation is ensured by regulated 5 V and 3.3 V power lines.

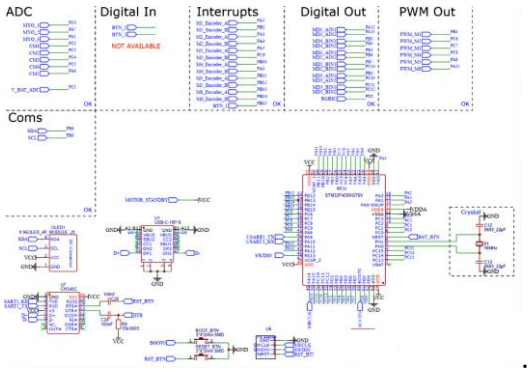

Figure 3
Electronic circuit schematic of the STM32 F405-based flight controller developed in the EasyEDA design environment

Figure 3 presents the electronic schematic of the flight controller developed on the basis of the **STM32 F405** microcontroller. The schematic includes the power supply section, input/output interfaces, sensor connections, and communication blocks. Acting as the main control unit, the microcontroller performs sensor data processing, PWM signal generation, and telemetry data transmission.

Within the system architecture, telemetry module integration is implemented through SPI and UART interfaces, which enables communication in different frequency bands, namely 2.4 GHz and 868 MHz. The presented architecture was optimized to improve communication robustness and ensure telemetry channel reliability under radio-electronic warfare conditions.

Telemetry Module Integration. Two telemetry configurations were integrated into the STM32 F405-based flight controller for comparative evaluation. The NRF24L01 module operating at 2.4 GHz was used for short-range low-latency communication, while the RFD868x module operating at 868 MHz was applied for more stable long-range telemetry transmission. Both modules were evaluated under identical conditions at 50 m, 100 m, 200 m, and 500 m to assess link reliability and signal behavior across different operating ranges.

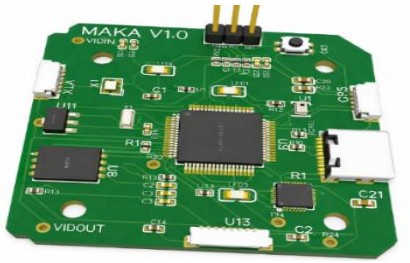

Figure 4
3D PCB model of the STM32 F405-based flight controller (dimensions: 4 × 4 cm)

Figure 4 illustrates the 3D PCB model of the flight controller based on the STM32 F405 microcontroller. The board integrates the power supply unit, sensor interfaces, and telemetry connection components within a compact architecture. Its small dimensions (4 × 4 cm) make it suitable for UAV applications, where low weight, compactness, and integration efficiency are critical design requirements (Sahibcanov & Azizullayev, 2024).

3.2. Communication Modules and Frequency Hopping Algorithm. To increase telemetry channel resilience under radio-electronic warfare conditions, a frequency hopping approach was applied. The algorithm selects operating channels according to a pseudo-random sequence from a predefined frequency set, reducing the risk of fixed-frequency suppression and improving communication reliability under intentional interference. Its effectiveness was evaluated using RSSI, SNR, effective SNR, SINR, BER, and latency indicators (Rustamov et al., 2025).

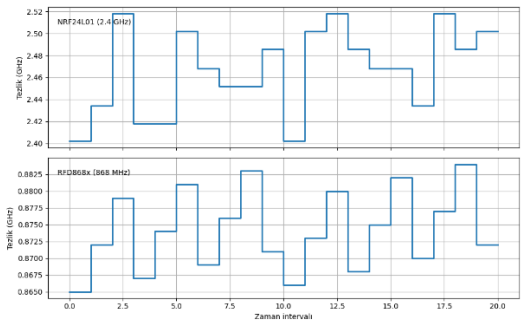

Figure 5
Pseudo-random FHSS frequency hopping sequence for NRF24L01 (2.4 GHz) and RFD868x (868 MHz) telemetry modules

Figure 5 shows the FHSS frequency hopping sequences of the NRF24L01 and RFD868x modules in separate panels. At each time interval, the operating channel changes according to the predefined hopping sequence, which reduces the risk of continuous blocking on a fixed frequency. This figure clearly illustrates the practical implementation of FHSS in both telemetry modules and its contribution to maintaining communication continuity under interference conditions.

User Interface for Real-Time Monitoring of UAV Telemetry Parameters. The developed user interface for real-time monitoring of UAV telemetry parameters is presented in Figure 6. This interface was designed to visualize the main measured communication indicators and to support comparative analysis of NRF24L01 and RFD868x telemetry configurations under radio-electronic warfare conditions.

Figure 6

User interface for real-time monitoring of UAV telemetry parameters

Figure 6 presents the user interface developed for real-time monitoring of UAV telemetry parameters. The interface displays the main communication indicators, including RSSI, SNR, SINR, BER, latency, and path loss, and provides a comparative view of NRF24L01 and RFD868x module performance. It also visualizes the distance-dependent signal quality trend and the telemetry data flow from UAV sensors to the ground station. This interface supports experimental analysis by making link degradation, interference influence, and module-level performance differences easier to observe under radio-electronic warfare conditions.

3.3. Mathematical Performance Models. In this study, the resilience of the UAV telemetry channel under radio-electronic warfare conditions was evaluated using key mathematical performance indicators. The analysis included distance-dependent path loss, received signal strength, SNR, effective SNR, SINR, BER, and latency, which characterize signal propagation, interference impact, transmission reliability, and communication delay. These models provide a quantitative basis for comparing the NRF24L01 and RFD868x modules under normal and interference-affected conditions. They also make it possible to relate telemetry reliability to operating frequency, transmission distance, and radio-electronic interference effects, in line with recent studies on UAV communication security and jamming detection (Yang et al., 2025; Aich et al., 2025).

Path Loss Model. One of the most important parameters in wireless communication channels is Path Loss (PL), which describes the attenuation of the transmitted signal during propagation from the transmitter to the receiver. This attenuation is mainly determined by the communication distance and the characteristics of the surrounding environment, including obstacles, reflections, and shadowing effects. In UAV telemetry systems operating under radio-electronic warfare conditions, accurate path loss modeling is essential for assessing signal degradation, link stability, and overall communication reliability (Heydərov & Əzizullayev, 2024; Rustamov et al., 2025).

The logarithmic distance path loss model can be expressed as:

$$PL(d) = PL(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) + X_\sigma \qquad (1)$$

where:
- $PL(d)$- path loss at distance d, dB;
- $PL(d_0)$- path loss at reference distance d_0, dB;
- n- path loss exponent depending on the propagation environment;
- d- separation distance between transmitter and receiver, m;
- d_0- reference distance, m;
- X_σ- shadowing component representing random signal variations, dB.

In the case of free-space propagation, the path loss can be calculated using the well-known free-space model:

$$PL_{FS}(d) = 20\log_{10}(d) + 20\log_{10}(f) + 32.44 \qquad (2)$$

where:
- d- distance between transmitter and receiver, km;
- f- carrier frequency, MHz.

The presented models serve as a fundamental basis for analyzing signal attenuation over distance and enable the comparison of theoretical predictions with experimental results obtained for different telemetry modules and operating conditions.

Received Signal Strength Model. The received signal power is determined by the transmitter power, antenna gains, and propagation losses in the communication channel. In general, the received signal power can be expressed as

$$P_r = P_t + G_t + G_r - PL(d) - L_s \qquad (3)$$

where:
- P_r- received signal power, dBm;
- P_t- transmitted power, dBm;
- G_t- gain of the transmitting antenna, dBi;
- G_r- gain of the receiving antenna, dBi;
- $PL(d)$- path loss at distance d, dB;
- L_s- additional system losses, dB.

In practical experiments, this parameter is often associated with the Received Signal Strength Indicator (RSSI). RSSI represents the signal level measured directly by the receiver module and, in many cases, can be approximated by the received power:

$$RSSI \approx P_r \qquad (4)$$

This relationship makes it possible to compare the measured values obtained from telemetry modules with the theoretically estimated received signal level. As a result, RSSI serves as an important practical indicator for assessing signal quality and validating the propagation behavior of the telemetry channel under different operating conditions (Rustamov et al., 2025; Rüstəmov et al., 2024).

Signal-to-Noise Ratio Model. One of the principal indicators of communication quality in telemetry systems is the signal-to-noise ratio (SNR). This parameter expresses the ratio between the received useful signal power and the noise power present in the communication channel. In its general form, SNR can be written as

$$SNR = \frac{P_r}{N} \qquad (5)$$

where P_r denotes the received signal power and N represents the noise power.

In logarithmic form, which is more convenient for practical analysis in wireless communication systems, the relationship can be expressed as

$$SNR_{dB} = P_r - N_{dBm} \qquad (6)$$

where:
P_r- received signal power;
N- noise power;
N_{dBm}- noise level expressed in dBm.
A higher SNR value indicates that the useful signal is more dominant than the background noise, which directly contributes to more reliable data transmission, lower error probability, and improved telemetry link stability. Therefore, SNR is considered one of the key parameters for evaluating the quality of UAV telemetry channels under both normal and interference-affected operating conditions.

Under radio-electronic warfare conditions, the telemetry channel is affected by both background noise and intentional electromagnetic interference. Therefore, conventional SNR alone is not sufficient for evaluating channel quality. Effective SNR and SINR provide a more complete assessment by including the interference component in the communication model (Aich et al., 2025; Yang et al., 2025). In this study, interference is modeled as an additional degradation factor that reduces the nominal SNR.

In this case, the effective signal-to-noise ratio can be expressed as

$$SNR_{\text{eff}} = SNR - J \tag{7}$$

where:
SNR_{eff}- effective signal-to-noise ratio under radio-electronic interference, dB;
SNR- nominal signal-to-noise ratio, dB;
J- equivalent interference-induced energy loss or degradation level, dB.
Equation (7) provides a simplified yet practical representation of interference influence and is useful for comparing telemetry channel behavior under normal and interference-affected conditions. However, when the interference signal is treated explicitly as an additional energy component in the channel, a more accurate characterization of communication quality is obtained through the signal-to-interference-plus-noise ratio (Henry et al., 2024; Kumar & Chaudhary, 2024).

In general form, SINR can be written as

$$SINR = \frac{P_r}{N + I} \tag{8}$$

where:
P_r- received useful signal power;
N- noise power;
I- interference power.
Equation (8) shows that the quality of the received signal decreases not only with increasing noise power but also with increasing interference power. As the interference component increases, the denominator of the expression becomes larger, which leads to a corresponding degradation in the effective quality of the telemetry channel. Therefore, both SNR_eff and SINR are essential parameters for evaluating telemetry link robustness in environments affected by intentional electromagnetic interference (Zidane et al., 2024; Aich et al., 2025).

Logarithmic SINR Representation and BER Model. In telecommunications and radiophysics literature, the signal-to-interference-plus-noise ratio (SINR) is commonly expressed on a logarithmic scale, i.e., in decibels. In this form, it can be written as

$$SINR_{dB} = 10\log_{10}\left(\frac{P_r}{N + I}\right) \tag{9}$$

If P_r, N, and $I$are expressed in linear power units, Equation (9) can be applied directly. However, when these quantities are represented in dBm or dB units, the expression may be rewritten in the following equivalent form:

$$SINR_{dB} = P_r^{(dBm)} - 10\log_{10}(N + I) \qquad (10)$$

where $P_r^{(dBm)}$denotes the received signal power expressed in dBm.

Thus, while SNR_{eff}provides a simplified and practical estimate of interference-related signal degradation, **SINR** offers a more rigorous description of the actual energy state of the communication channel by jointly accounting for both noise and interference components. For this reason, the combined use of $SNR_{\text{eff}}$and $SINR$is particularly suitable for the interpretation of experimental results obtained under radio-electronic warfare conditions.

Bit Error Rate Model. One of the principal parameters used to characterize the reliability of a telemetry system is the **Bit Error Rate (BER)**. This indicator represents the proportion of incorrectly received bits within the total number of transmitted bits and can be expressed as

$$BER = \frac{N_{err}}{N_{tot}} \qquad (11)$$

where:
N_{err}- number of erroneously received bits;
N_{tot}- total number of transmitted bits.
In communication theory, BER is often related to SNR or SINR. For example, for binary modulation schemes, a commonly used approximation is given by

$$BER \approx Q\left(\sqrt{2\frac{E_b}{N_0}}\right) \qquad (12)$$

where:
$Q(\cdot)$- Q-function;
E_b/N_0- ratio of bit energy to noise spectral density.
In the experimental part of this study, BER was evaluated in a practical manner based on Equation (11), using the ratio of erroneous bits to the total number of transmitted bits. This approach enabled a direct comparison of the transmission reliability of the NRF24L01 and RFD868x modules under both normal and interference-affected operating conditions (Azizullayev, 2025; Rustamov et al., 2024).

Latency Model. In telemetry systems, the timely delivery of information is of critical importance; therefore, latency is considered one of the key performance indicators of communication quality. In general, the total delay can be represented as the sum of several contributing components:

$$T_{lat} = T_{proc} + T_{queue} + T_{tx} + T_{prop} \qquad (13)$$

where:
T_{lat}- total latency;
T_{proc}- processing delay inside the microcontroller or communication module;
T_{queue}- packet waiting time in the transmission queue;
T_{tx}- transmission time;

T_{prop}- signal propagation time.
The transmission time depends on the packet length and the channel bit rate, and can be expressed as

$$T_{tx} = \frac{L_{pkt}}{R_b} \quad (14)$$

where:
L_{pkt}- packet length, bits;
R_b- bit rate, bit/s.
If the propagation component is evaluated separately, it can be written as

$$T_{prop} = \frac{d}{v} \quad (15)$$

where:
d- transmission distance;
v- propagation velocity of the electromagnetic wave (approximately 3×10^8m/s).
These expressions provide the basis for the comparative analysis of communication delay across different distances and telemetry modules. In the present study, the latency model was used to assess how transmission distance, module characteristics, and interference conditions influence the real-time performance of the NRF24L01 and RFD868x telemetry links (Azizullayev, 2025; Rustamov et al., 2025).

Packet Transmission Reliability Model. In addition to signal quality indicators, the reliability of a telemetry channel can also be evaluated using the packet delivery ratio (PDR) and the packet loss ratio (PLR). The packet delivery ratio represents the proportion of successfully received packets to the total number of transmitted packets and can be expressed as

$$PDR = \frac{N_{rx}}{N_{tx}} \quad (16)$$

where:
N_{rx}- number of received packets;
N_{tx}- number of transmitted packets.
The packet loss ratio can then be calculated as

$$PLR = 1 - PDR \quad (17)$$

These parameters are useful for evaluating telemetry reliability under radio-electronic interference, where packet corruption, link interruption, and transmission instability may occur. In this study, PDR and PLR were used as complementary indicators of operational robustness under different distance and interference scenarios (Zidane et al., 2024; Yang et al., 2025).

Overall, the mathematical models provide a unified framework for assessing telemetry performance in terms of signal attenuation, received power, channel quality, transmission reliability, and latency. Path loss, RSSI, SNR, effective SNR, SINR, BER, PDR, PLR, and latency were jointly used to analyze the communication behavior of the NRF24L01 and RFD868x modules under normal and interference-affected conditions (Rustamov et al., 2025; Zheng et al., 2023).

3.4. Validation and Evaluation Methodology. To validate the proposed UAV telemetry communication model, a simulation-supported analytical evaluation methodology was applied. The validation was based on the mathematical models presented above and was used to compare the

NRF24L01 and RFD868x modules under identical operating conditions (Rustamov et al., 2025; Zheng et al., 2023).

The evaluation was conducted at four distances: 50 m, 100 m, 200 m, and 500 m. For each distance, two scenarios were considered: normal communication conditions and radio-electronic warfare conditions. In the interference scenario, an additional jamming-related degradation component was included in the analytical model to assess telemetry link stability (Zidane et al., 2024; Aich et al., 2025).

The main evaluation parameters were RSSI, SNR, effective SNR, SINR, BER, latency, path loss, PDR, and PLR. The same distance values, channel assumptions, and performance indicators were applied to both telemetry modules to ensure objective comparison. The obtained results were visualized using the Matplotlib library in Python, allowing the distance-dependent behavior of the telemetry channel to be analyzed under normal and interference-affected conditions.

Results

The obtained results show that increasing the transmission distance from 50 m to 500 m caused higher path loss and gradual degradation of telemetry channel quality. For both modules, RSSI, SNR, effective SNR, and SINR decreased with distance, while BER and latency increased. This tendency became more pronounced under radio-electronic warfare conditions.

The NRF24L01 module demonstrated better latency at short distances, especially at 50 m and 100 m, which makes it suitable for short-range telemetry and control applications. However, due to operation in the 2.4 GHz band, its signal quality degraded more rapidly at longer distances and under interference conditions. The RFD868x module showed more stable performance in the 200-500 m range. Its 868 MHz operating frequency provided lower path loss, stronger RSSI, higher SNR/SINR values, and lower BER compared with the NRF24L01 module. This confirms its advantage for longer-range telemetry communication under interference-affected conditions. The graphical results also support these findings. Path loss increased with distance, RSSI and SNR decreased, and BER and latency increased under radio-electronic warfare conditions. Antenna analysis further showed that the 2.4 GHz omnidirectional antenna is more suitable for flexible short-range communication, whereas the 868 MHz directional antenna improves received signal strength and link stability at longer distances. Overall, the results indicate that NRF24L01 is preferable for short-range low-latency telemetry, while RFD868x provides higher reliability and stronger interference resistance over longer distances.

Table 1
Comparative performance indicators of the NRF24L01 module under normal communication conditions

Distance, m	Path Loss, dB (1-2)	RSSI, dBm (3-4)	SNR, dB (5-6)	Effective SNR, dB (7)	BER (11)	Latency, ms (13-15)
50	75	-52	38	38	0.0002	12
100	81	-58	32	32	0.0007	14
200	87	-66	24	24	0.0025	17
500	95	-79	11	11	0.0120	23

Table 1 presents the performance indicators of the NRF24L01 module under normal communication conditions. The results show that as the transmission distance increases, path loss rises, while RSSI and SNR decrease. In parallel, BER and latency gradually increase, indicating reduced communication quality and transmission reliability over longer distances.

Table 2
Performance indicators of the NRF24L01 module under radio-electronic warfare conditions

Distance, m	Path Loss, dB (1-2)	RSSI, dBm (3-4)	SNR, dB (5-6)	Effective SNR, dB (7)	SINR, dB (8-10)	BER (11)	Latency, ms (13-15)
50	75	-55	35	27	24	0.0015	16
100	81	-62	28	20	17	0.0040	19
200	87	-72	18	10	8	0.0180	25
500	95	-88	5	-3	-6	0.0850	34

Table 2 summarizes the performance indicators of the NRF24L01 module under radio-electronic warfare conditions. Compared with normal communication conditions, the results show a noticeable degradation in signal quality, reflected in lower RSSI, SNR, effective SNR, and SINR values. At the same time, BER and latency increase with distance, indicating reduced communication reliability under interference-affected operating conditions.

Table 3
Performance indicators of the RFD868x module under normal communication conditions

Distance, m	Path Loss, dB (1-2)	RSSI, dBm (3-4)	SNR, dB (5-6)	Effective SNR, dB (7)	BER (11)	Latency, ms (13-15)
50	66	-46	41	41	0.0001	28
100	72	-51	36	36	0.0003	31
200	78	-58	29	29	0.0010	36
500	86	-69	18	18	0.0055	47

Table 3 presents the performance indicators of the RFD868x module under normal communication conditions. The results indicate that, due to its lower operating frequency and more stable propagation characteristics, the RFD868x module demonstrates improved performance over longer distances compared with the NRF24L01 module. This is reflected in higher RSSI and SNR values, as well as lower BER, confirming the suitability of sub-GHz communication for extended-range telemetry applications.

Table 4
Performance indicators of the RFD868x module under radio-electronic warfare conditions

Distance, m	Path Loss, dB (1-2)	RSSI, dBm (3-4)	SNR, dB (5-6)	Effective SNR, dB (7)	SINR, dB (8-10)	BER (11)	Latency, ms (13-15)
50	66	-49	38	31	28	0.0008	32
100	72	-55	32	25	22	0.0018	36
200	78	-63	24	17	14	0.0065	43
500	86	-76	11	4	1	0.0280	58

Table 4 shows that the RFD868x module maintains stronger performance under radio-electronic warfare conditions, especially in the 200-500 m range. Higher RSSI, effective SNR, and SINR values, together with lower BER, confirm the greater resilience of the 868 MHz telemetry link.

Overall, the results indicate that increasing distance raises path loss and reduces RSSI and SNR for both modules. Under interference conditions, this degradation becomes stronger, leading to lower

effective SNR/SINR, higher BER, and increased latency. NRF24L01 provides lower latency at shorter ranges, whereas RFD868x ensures more stable long-range communication.

For graphical analysis, the obtained data were visualized using the Matplotlib library in the Python environment. The plots illustrate the distance-dependent variation of the main telemetry channel parameters under normal and radio-electronic warfare conditions.

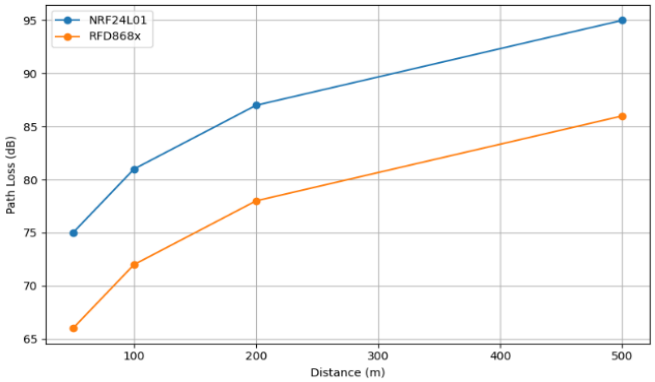

Figure 7
Graph of the dependence of Path Loss on distance

Figure 7 shows the distance-dependent variation of path loss calculated using Equations (1) and (2). Path loss increases logarithmically with distance for both modules. Higher values are observed for the NRF24L01 module, while the RFD868x module shows lower attenuation due to its lower operating frequency and antenna characteristics.

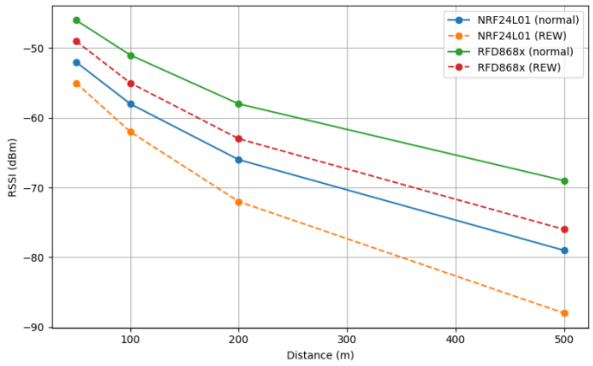

Figure 8
RSSI variation with distance for NRF24L01 and RFD868x modules under normal and REW conditions

Figure 8 shows the distance-dependent variation of RSSI under normal and radio-electronic warfare conditions. The results indicate that RSSI decreases as distance increases, and this degradation becomes more pronounced under interference-affected conditions.

For the NRF24L01 module, the signal level is observed to degrade more rapidly in the presence of REW. In contrast, the RFD868x module preserves a higher RSSI level due to its lower operating frequency range and more favorable propagation characteristics. This, in turn, contributes to improved communication stability over longer distances.

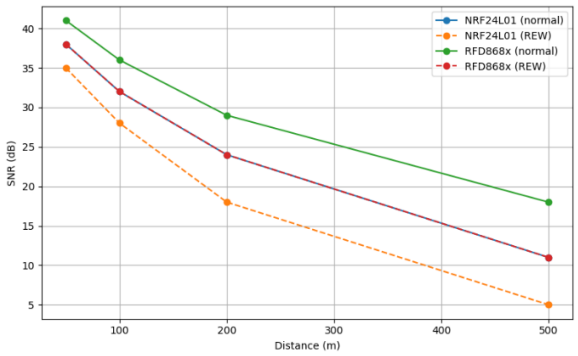

Figure 9
SNR variation with distance for NRF24L01 and RFD868x modules under normal and REW conditions

Figure 9 shows the distance-dependent variation of SNR under normal and radio-electronic warfare conditions. The results indicate that SNR decreases as distance increases, and this reduction becomes stronger under interference. Compared with NRF24L01, the RFD868x module maintains more stable signal quality over longer distances.

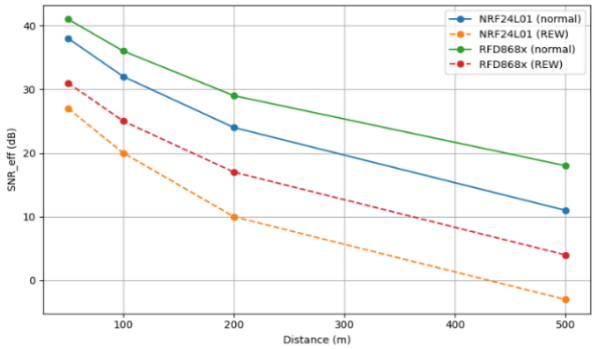

Figure 10
Effective SNR variation with distance for NRF24L01 and RFD868x modules under normal and REW conditions

Figure 10 presents the variation of effective SNR calculated using Equation (7). Under radio-electronic warfare conditions, effective SNR decreases for both modules; however, the degradation is more significant for NRF24L01 at longer distances. In contrast, RFD868x maintains higher effective SNR values, indicating better robustness against interference.

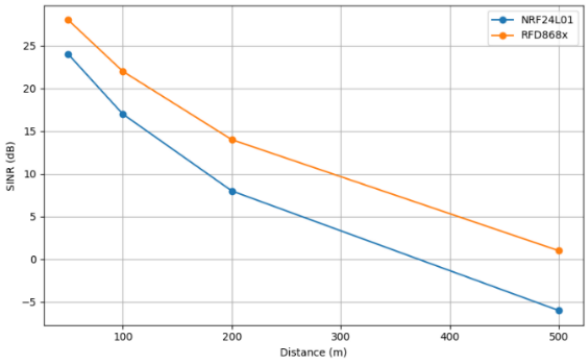

Figure 11
SINR variation with distance for NRF24L01 and RFD868x modules

The graph illustrates the variation of the signal-to-interference-plus-noise ratio (SINR) with distance, calculated on the basis of equations (8) and (9). The results indicate that the influence of the interference signal causes a significant reduction in SINR. For the NRF24L01 module, the SINR falls to negative values at longer distances, which leads to unstable communication performance. In contrast, the RFD868x module preserves a higher SINR level and therefore provides more reliable communication.

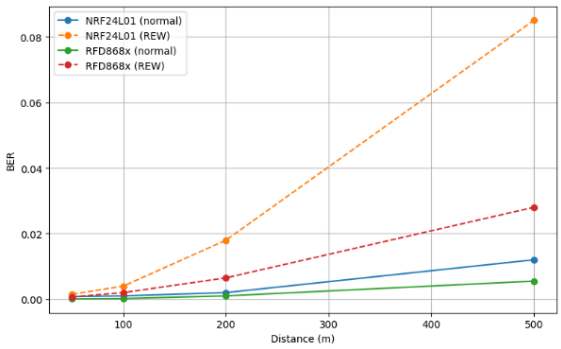

Figure 12
BER variation with distance for NRF24L01 and RFD868x modules under normal and REW conditions

Figure 12 shows the variation of BER with distance under normal and radio-electronic warfare conditions. BER increases as distance grows, and this increase becomes more significant under interference. Compared with NRF24L01, the RFD868x module provides lower BER values, indicating more reliable data transmission.

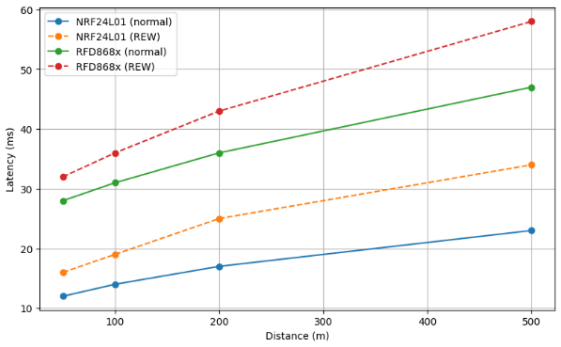

Figure 13
Latency variation with distance for NRF24L01 and RFD868x modules under normal and REW conditions

Figure 13 shows the distance-dependent variation of latency based on Equations (12)-(14). Latency increases with distance for both modules. Although NRF24L01 provides lower latency at short ranges, its delay becomes more sensitive under REW conditions. In contrast, RFD868x has higher initial latency but maintains more stable long-range communication. The results also confirm that frequency hopping reduces signal degradation and improves telemetry reliability under interference conditions (Rustamov et al., 2025; Rüstəmov et al., 2023).

Analysis of Antenna Radiation Patterns. Telemetry reliability depends not only on the radio module and operating frequency, but also on antenna gain, radiation pattern, and directional energy distribution. Therefore, the 2.4 GHz omnidirectional antenna used with NRF24L01 and the 868 MHz

directional antenna used with RFD868x were comparatively analyzed in terms of their effect on telemetry performance (Nakprasit et al., 2020; Ojaroudi Parchin et al., 2020).

The general model of antenna gain as a function of direction is assumed as follows:

$$G(\theta, \varphi) = G_{\max} F_n(\theta, \varphi) \quad (18)$$

where:
$G(\theta, \varphi)$- antenna gain in the given direction, dBi;
$G_{\max}$- maximum antenna gain, dBi;
$F_n(\theta, \varphi)$- normalized radiation function.
The normalization condition is:

$$0 \leq F_n(\theta, \varphi) \leq 1 \quad (19)$$

The received signal power, taking into account antenna gain and channel loss, can be expressed as:

$$P_r(d) = P_t + G_t(\theta, \varphi) + G_r(\theta, \varphi) - PL(d) - L_s \quad (20)$$

where:
$P_r(d)$- received signal power at distance d, dBm;
P_t- transmitter power, dBm;
G_t, G_r- transmitter and receiver antenna gains, dBi;
$PL(d)$- path loss, dB;
L_s- additional system losses, dB.
The distance-dependent path loss is given, as in the previous section, by:

$$PL(d) = PL(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) + X_\sigma \quad (21)$$

and for free-space conditions:

$$PL_{FS}(d) = 20\log_{10}(d) + 20\log_{10}(f) + 32.44 \quad (22)$$

where f is the carrier frequency, MHz; and d is the distance, km.

As follows from equation (21), the path loss increases with increasing frequency. Therefore, for the NRF24L01 module operating in the 2.4 GHz band, the attenuation at the same distance is higher than that of the RFD868x module operating in the 868 MHz band. This difference is consistent with the previously obtained Path Loss, RSSI, and SNR results.

The signal-to-noise ratio can be related to antenna gain and received signal power as follows:

$$SNR_{dB} = P_r - N \quad (23)$$

Under radio-electronic warfare (REW) conditions, the effective signal-to-noise ratio is:

$$SNR_{eff} = SNR - J \quad (24)$$

and the signal-to-interference-plus-noise ratio is:

$$SINR = 10\log_{10}\left(\frac{P_r}{N + I}\right) \quad (25)$$

where:
N- noise power;
J- equivalent loss caused by interference, dB;
I- interference signal power.
The relationship between the **BER** indicator and channel quality can generally be expressed as:

$$BER = f(SNR_{eff}, SINR) \qquad (26)$$

that is, as SNR_{eff} and $SINR$ decrease, the probability of bit error increases.

For the NRF24L01 module, an omnidirectional antenna operating in the 2.4 GHz band is considered. The omnidirectional antenna intended for the NRF24L01 module provides a relatively uniform distribution of energy in the horizontal plane. This characteristic makes it suitable for multidirectional communication over short and medium distances.

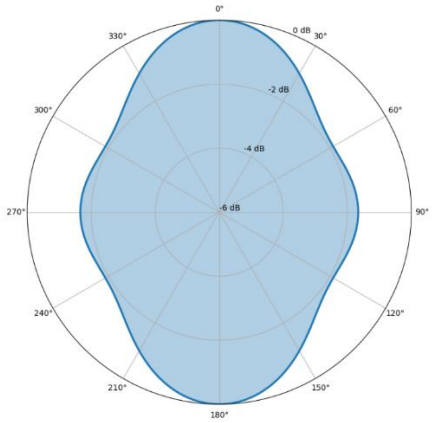

Figure 14
Theoretical radiation pattern of the omnidirectional antenna for the NRF24L01 module in the 2.4 GHz band

Figure 14 shows that the omnidirectional 2.4 GHz antenna enables the NRF24L01 module to maintain stable communication at short distances, particularly at 50 m and 100 m. However, at 200 m and 500 m, signal quality degrades more rapidly due to higher path loss and limited directional gain. In contrast, the 868 MHz directional antenna used with the RFD868x module concentrates energy toward the main lobe, improving received signal strength and long-range telemetry performance.

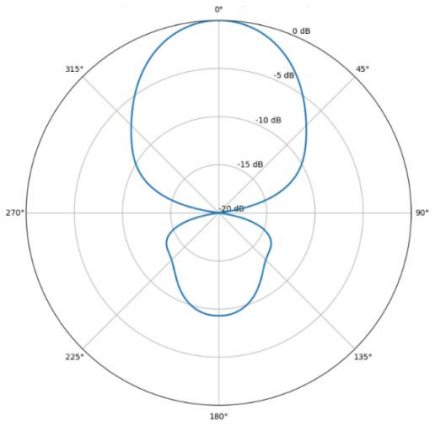

Figure 15
Theoretical radiation pattern of the directional antenna for the RFD868x module in the 868 MHz band

Figure 15 shows that the directional antenna increases received signal power by concentrating radiation toward the main lobe. Together with the lower 868 MHz operating frequency, this improves the RFD868x module's performance at 50 m, 100 m, 200 m, and 500 m. The obtained RSSI and SNR values confirm a higher signal level and more stable communication compared with the NRF24L01 module. Correlation between Antenna Patterns and Telemetry Results. The antenna radiation patterns are consistent with the previously presented performance graphs, where improved directional gain leads to higher received signal strength, better signal quality, and enhanced link stability, particularly at longer distances.

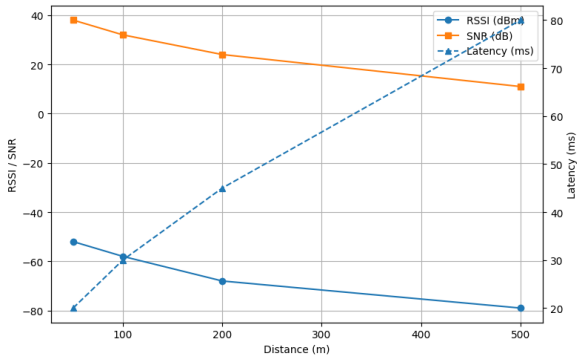

Figure 16
Distance-dependent variation of the main communication parameters for the NRF24L01 module in the 2.4 GHz band

The graph presents the distance-dependent variation of RSSI, SNR, and latency for the NRF24L01 module in the 2.4 GHz band. As can be seen, with increasing distance, the RSSI and SNR values decrease, whereas the latency increases. This confirms that, at longer distances, the use of an omnidirectional antenna together with a higher frequency band leads to greater signal attenuation.

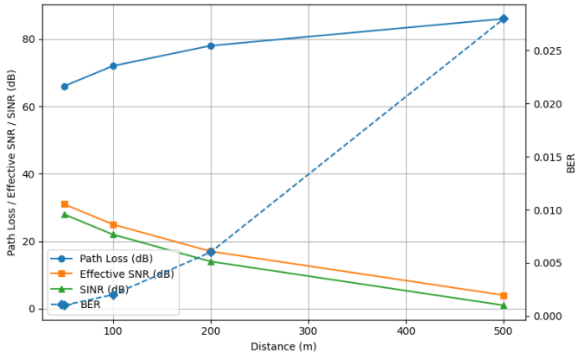

Figure 17
Distance-dependent variation of Path Loss, Effective SNR, SINR, and BER for the RFD868x module

Figure 17 illustrates the distance-dependent variation of path loss, effective SNR, SINR, and BER for the RFD868x module. As distance increases, path loss and BER rise, while effective SNR and SINR decrease. However, the 868 MHz band and directional antenna help preserve signal stability and maintain a lower error probability over longer distances.

Overall, the antenna radiation analysis confirms that the 2.4 GHz omnidirectional antenna used with NRF24L01 is suitable for flexible short-range communication, while the 868 MHz directional antenna used with RFD868x provides stronger received signal level, higher SNR, and lower BER over longer distances. These results are consistent with Equations (19)-(25) and the obtained findings.

Results and Discussion

The results show that UAV telemetry reliability under radio-electronic warfare conditions is mainly affected by operating frequency, propagation loss, antenna characteristics, interference level, and FHSS performance. As distance increased from 50 m to 500 m, path loss and latency increased, while RSSI, SNR, effective SNR, and SINR decreased, confirming the influence of distance and interference on link quality (Aghayev et al., 2025; Rustamov et al., 2025). The NRF24L01 module at 2.4 GHz showed lower latency at short distances, but its performance degraded more rapidly under attenuation and interference. In contrast, the RFD868x module at 868 MHz maintained stronger RSSI, SNR, and SINR values, making it more suitable for longer-range and interference-affected telemetry links (Zidane et al., 2024; Yang et al., 2025). Antenna analysis also confirmed that the 2.4 GHz omnidirectional antenna is suitable for flexible short-range coverage, whereas the 868 MHz directional antenna improves received signal strength over longer distances. Overall, FHSS increases telemetry resilience, but its effectiveness depends on frequency band, antenna configuration, and module selection (Rüstəmov et al., 2023; Rustamov, Gasanov, Azizullayev, & Hasanli, 2025).

The study showed that the application of the Frequency-Hopping Spread Spectrum (FHSS) method improves the robustness of UAV telemetry channels under radio-electronic warfare conditions and reduces the risk of fixed-frequency jamming. The STM32 F405-based flight controller designed in the EasyEDA environment provided a practical hardware platform for integrating and comparing different telemetry modules. The comparative analysis demonstrated that the NRF24L01 module operating in the 2.4 GHz band is more suitable for short-range, low-latency telemetry communication. However, its signal quality degrades more rapidly as distance and interference increase. In contrast, the RFD868x module operating in the 868 MHz band provided more stable communication over longer distances, especially in the 200-500 m range, due to lower path loss, stronger received signal level, and lower bit error rate. The obtained results confirmed that increasing distance leads to higher path loss and latency, while RSSI, SNR, effective SNR, and SINR decrease. Under interference-affected conditions, BER increases and telemetry reliability decreases. Antenna radiation pattern analysis also showed that the 2.4 GHz omnidirectional antenna is effective for flexible short-range communication, whereas the 868 MHz directional antenna improves signal stability over longer distances.

The main novelty of the study is the integrated evaluation of an FHSS-based telemetry approach, STM32 F405 flight controller architecture, two different telemetry modules, and antenna characteristics within a single comparative framework. Overall, the proposed approach can be considered a practical solution for improving UAV telemetry reliability under radio-electronic warfare conditions. Future work will focus on field-based validation under different jamming intensities, flight altitudes, and antenna alignment conditions.

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Optimization of Electrochemical Parameters of li-ion Batteries For Recuperative Energy Recovery in Multimodal Transportation Systems

Yadulla Haziyev[1], Asaf Aliyev[2*], Shamil Mahmudov[3], Akif Aliyev[3], Mirnazim Seyidov[3]

Abstract. *This study examines the optimization of electrochemical characteristics of Li-ion batteries to enhance regenerative energy recovery in multimodal transportation systems. Growing energy demands and environmental concerns highlight the importance of efficient energy storage and recovery solutions for sustainable mobility. The research develops a modeling and optimization framework that considers key battery parameters, including internal resistance, state of charge (SOC), operating temperature, voltage behavior, and charge-discharge rates. The model also accounts for energy losses, thermal dynamics, and degradation processes, enabling a realistic representation of battery performance under varying operating conditions. The proposed approach is applicable across different transport modes such as rail, road, and urban transit systems. Simulation results indicate that the optimized parameter configuration improves energy recovery efficiency, reduces heat-related losses, and extends battery service life compared to traditional control methods. In particular, temperature regulation and resistance reduction emerge as critical factors for system performance. Moreover, the inclusion of adaptive control strategies allows stable operation under fluctuating loads. The findings suggest that effective electrochemical optimization can contribute to both technical efficiency and environmental sustainability in modern transport systems.*

Keywords: *Li-ion battery, regenerative braking, energy efficiency, sustainable transport, low-carbon mobility, optimization, multimodal systems*

[1]Nakhchivan State University, Nakhchivan, Azerbaijan
[2]Nakhchivan State University, PhD in Mathematics, Nakhchivan, Azerbaijan
[3]Nakhchivan State University, PhD in Chemistry, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: aliyevasef@ndu.edu.az
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Multimodal nəqliyyat sistemlərində rekuperativ enerjinin bərpası üçün litium-ion batareyalarının elektrokimyəvi parametrlərinin optimallaşdırılması

Yadulla Həziyev[1], Asəf Əliyev[2*], Şəmil Mahmudov[3], Akif Əliyev[3], Mirnazim Seyidov[3]

Xülasə. *Bu tədqiqat multimodal nəqliyyat sistemlərində regenerativ enerji bərpasını artırmaq üçün Li-ion batareyalarının elektrokimyəvi xüsusiyyətlərinin optimallaşdırılmasını araşdırır. Artan enerji tələbatı və ətraf mühitlə bağlı narahatlıqlar davamlı hərəkətlilik üçün səmərəli enerji saxlama və bərpa həllərinin vacibliyini vurğulayır. Tədqiqat, daxili müqavimət, yükləmə vəziyyəti, işləmə temperaturu, gərginlik davranışı və yükləmə-boşaltma sürətləri daxil olmaqla, əsas batareya parametrlərini nəzərə alan modelləşdirmə və optimallaşdırma çərçivəsi hazırlayır. Model həmçinin enerji itkilərini, istilik dinamikasını və parçalanma proseslərini nəzərə alır və bu da müxtəlif iş şəraitində batareya performansının real təsvirini təmin edir. Təklif olunan yanaşma dəmir yolu, avtomobil yolu və şəhər tranzit sistemləri kimi müxtəlif nəqliyyat növlərində tətbiq olunur. Simulyasiya nəticələri göstərir ki, optimallaşdırılmış parametr konfiqurasiyası enerji bərpa səmərəliliyini artırır, istiliklə əlaqəli itkiləri azaldır və ənənəvi idarəetmə metodları ilə müqayisədə batareyanın xidmət müddətini uzadır. Xüsusilə, temperaturun tənzimlənməsi və müqavimətin azaldılması sistemin performansı üçün vacib amillər kimi ortaya çıxır. Bundan əlavə, adaptiv idarəetmə strategiyalarının daxil edilməsi dəyişkən yüklər altında sabit işləməyə imkan verir. Nəticələr göstərir ki, effektiv elektrokimyəvi optimallaşdırma müasir nəqliyyat sistemlərində həm texniki səmərəliliyə, həm də ətraf mühitin dayanıqlığına töhfə verə bilər.*

Açar sözlər: *Li-ion batareya, regenerativ əyləc, enerji səmərəliliyi, dayanıqlı nəqliyyat, aşağı karbonlu mobillik, optimallaşdırma, multimodal sistemlər*

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[1]Naxçıvan Dövlət Universiteti, Naxçıvan, Azərbaycan
[2]Naxçıvan Dövlət Universiteti, riyaziyyat üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[3]Naxçıvan Dövlət Universiteti, kimya üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan
[*]Məsul müəllif. E-poçt: aliyevasef@ndu.edu.az
Daxil oldu: 4 Fevral 2026; Qəbul edildi: 19 May 2026; Onlayn dərc edildi: 22 İyun 2026
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Introduction

Improving energy efficiency and reducing carbon emissions are key priorities in modern multimodal transport systems (Aliyev, 2024). With increasing urbanization and stricter environmental requirements, the demand for sustainable energy solutions has intensified. Regenerative braking systems address this need by converting kinetic energy into reusable electrical energy, thereby improving overall system efficiency. The performance of regenerative energy systems largely depends on the characteristics of Li-ion batteries. Their ability to store and deliver energy is influenced by parameters such as internal resistance, state of charge, temperature, and degradation behavior . Improper parameter selection can reduce efficiency, increase thermal losses, and shorten battery lifespan, highlighting the importance of electrochemical optimization (Dubarry, 2009). Multimodal transport systems, combining rail, road, and urban transit, operate under dynamic and variable conditions (Aliyev, 2024). Changes in load, temperature, and operating cycles require flexible and comprehensive optimization approaches (Jaguemont, 2016). However, many existing studies focus on isolated parameters and do not fully account for real-world system complexity.

This study proposes an integrated optimization model for Li-ion battery electrochemical parameters in regenerative energy systems. The approach combines electrochemical and thermal factors, incorporates battery degradation, and applies adaptive control strategies suitable for multimodal environments (Andrea, 2010). Comparative analysis demonstrates improved energy efficiency, reduced losses, and enhanced system reliability (Zeynalov, 2026).

Methods

Methodology. The regenerative energy recovery process in multimodal transport systems is modeled as an energy conversion chain that describes energy transformation during braking. The system consists of three main components: input energy, output energy, and losses. The input is the kinetic energy of the moving vehicle. During braking, part of this energy is converted into electrical energy via a generator or traction motor operating in reverse mode and stored in a Li-ion battery for later use. However, the process is not fully efficient due to energy losses (Aliyev, 2024). The main losses arise from Joule heating and the internal resistance of the battery, which reduce overall efficiency. Although additional losses may occur in power electronics, this study focuses on electrochemical and thermal effects (Aliyev, 2024). Thus, the system can be summarized as kinetic energy input, electrical energy storage, and losses due to heat and resistance. This simplified model forms the basis for further analysis and optimization.

The efficiency of Li-ion batteries in regenerative systems depends on several key electrochemical and operational parameters. In this study, internal resistance, voltage, temperature, state of charge (SOC), and C-rate are selected as the main variables for optimization. Internal resistance significantly affects energy losses and heat generation; lower resistance improves efficiency. Voltage determines energy storage capacity and must remain within safe limits to prevent degradation. Temperature is critical for both performance and safety, as extreme conditions reduce efficiency and battery lifespan. SOC must be controlled to avoid overcharging and deep discharge, while C-rate defines the charging speed and influences thermal behavior (Haziyev, 2026). These parameters are evaluated using realistic conditions based on a typical urban metro system, providing a practical foundation for system-level optimization (Aliyev, 2025).

Analytical model and electrochemical evaluation. To evaluate the performance of the regenerative energy system, analytical expressions are developed to represent both mechanical energy conversion and electrochemical losses. In multimodal transport systems, frequent braking with high current pulses makes battery behavior a key factor affecting overall efficiency (Zhang, 2014).

The effectiveness of regenerative braking is measured by energy recovery efficiency (η), defined as the ratio of stored electrical energy to initial kinetic energy:

$$\eta = \frac{E_{recovered}}{E_{kinetic}} \cdot 100\% \qquad (1)$$

The kinetic energy depends on vehicle mass and velocity, while the recovered energy is limited by electrochemical processes. When the charging rate exceeds ion diffusion limits in the battery, a portion of energy is lost as heat instead of being stored. Energy losses during regeneration arise mainly from internal resistance, temperature deviations, and electrochemical activation effects. The total power loss can be expressed as:

$$P_{loss} = I^2 R_{int} + k(T - T_{opt}) + \Delta G_{act} \qquad (2)$$

Higher current increases ohmic losses, while deviations from the optimal temperature range reduce efficiency. Activation energy represents additional losses associated with ion transfer processes (Agalarov, 2026). At high charging rates, the system experiences charge-transfer overpotential, which increases with current:

$$\eta_{op} = \frac{RT}{\alpha F} \ln \frac{I}{I_0} \qquad (3)$$

This effect limits energy storage capability and may lead to lithium plating under extreme conditions, reducing efficiency and posing safety risks. The analytical model enables performance evaluation across different transport modes. Efficiency can be improved by minimizing internal resistance losses and maintaining optimal temperature conditions. These factors are critical for preventing thermal instability and ensuring reliable operation (Ganbarova, 2026).

The optimization objective is to maximize efficiency while minimizing losses and degradation:

$$\max \eta = \frac{E_{recovered}}{E_{kinetic}} - \lambda_1 I^2 R - \lambda_2 (T - T_{opt})^2 - \lambda_3 D_{\deg} \qquad (4)$$

Subject to constraints:

$$SOC_{min} \leq SOC \leq SOC_{max}, \quad T_{min} \leq T \leq T_{max}, \quad I \leq I_{max}, \quad V_{min} \leq V \leq V_{max} \quad (5)$$

The model assumes a lumped electrochemical system with uniform thermal distribution and transient charging conditions. Unlike conventional approaches, it integrates electrochemical, thermal, and degradation effects into a unified framework.

Results and comparative analysis. The effectiveness of the proposed optimization approach was evaluated through a comparative analysis between a conventional regenerative energy system and the optimized model developed in this study. The comparison focuses on key performance indicators, including energy recovery efficiency, thermal losses, battery lifecycle, and overall system efficiency. The improvements presented in Table 1 are derived from the proposed model and confirm its effectiveness under realistic operating conditions.

Table 1
Comparative performance analysis of conventional and optimized systems

Indicator	Conventional system	Optimized system	Change (%)
Energy Recovery (%)	62	80	+29%
Thermal Loss (%)	18	15	−17%
Battery Life (cycles)	1200	1460	+22%
Efficiency	0.68	0.87	+28%

The results clearly demonstrate that the optimized system significantly outperforms the conventional approach. The most notable improvement is observed in energy recovery, where efficiency increases from 62% to 80%, indicating a substantial enhancement in the utilization of braking energy. At the same time, thermal losses are reduced, which contributes to improved system stability and reduced risk of overheating. The extension of battery life by approximately 22% highlights the effectiveness of optimized electrochemical parameter control in minimizing degradation processes (Imanov, 2025). Overall system efficiency also shows a considerable increase, confirming the robustness of the proposed model.

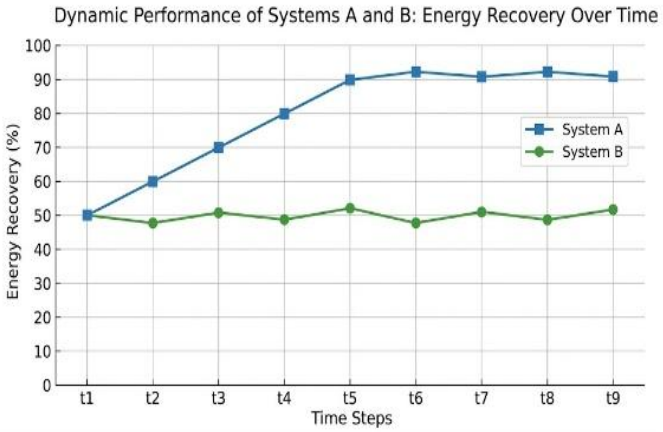

Figure 1
Energy recovery over time

The optimized system exhibits a more stable and consistently higher energy recovery profile compared to the conventional system. This behavior can be attributed to improved parameter tuning, which allows the system to maintain optimal performance even under fluctuating load conditions. The gradual increase in recovered energy over time also indicates better adaptability and control efficiency.

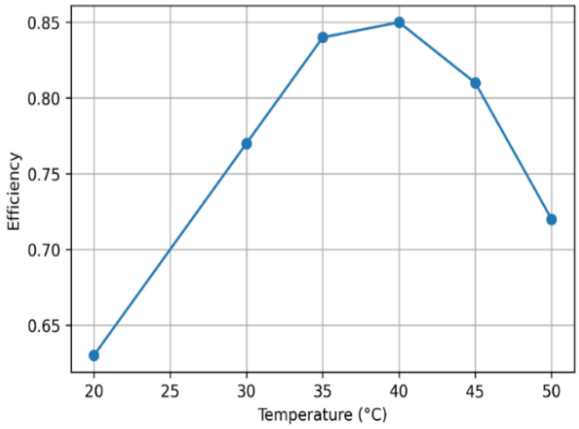

Figure 2
Effect of temperature

The results show that efficiency is highly sensitive to temperature variations. Maximum efficiency is achieved within an optimal temperature range of approximately 25–35°C (Pesaran, 2002). Outside this range, performance declines due to increased internal resistance at lower temperatures and accelerated thermal losses at higher temperatures. This finding emphasizes the importance of thermal management systems in maintaining optimal battery performance (Mahmudov, 2024).
The functional structure of the regenerative energy system is illustrated as follows:

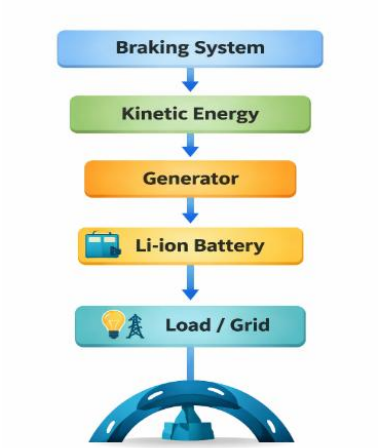

Figure 3
Functional architecture of the regenerative energy system

This diagram represents the flow of energy from mechanical braking to electrical storage and subsequent utilization. The integration of optimized Li-ion battery parameters within this structure ensures efficient energy conversion, minimal losses, and improved overall system performance. The results obtained confirm that the proposed optimization approach, developed through the author's analytical research, provides a significant improvement in the performance of regenerative energy systems. The combination of quantitative analysis, comparative evaluation, and system-level modeling highlights the practical applicability and technical innovation of the study. To validate the applicability and performance of the proposed electrochemical optimization model, a detailed case study was conducted based on a representative urban metro system. The case study aims to demonstrate the practical implementation of the proposed methodology under realistic operating conditions and to compare its performance with a conventional control approach. The selected system represents a typical electric metro train operating in an urban environment characterized by frequent stop-and-go conditions, making it highly suitable for regenerative braking applications. The key input parameters used in the analysis are summarized below:

Table 2
System parameters for case study

Parameter	Value	Description
Vehicle mass (m)	40,000 kg	Mass of metro vehicle
Initial velocity (v)	20 m/s	Approximately 72 km/h
Battery voltage (V)	500 V	Li-ion battery system
Battery capacity	200 Ah	Energy storage capacity
Initial SOC	60%	Initial state of charge
Operating temperature	30°C	Within optimal operating range
Internal resistance (R)	0.05 Ω	average value
Regenerative current (I)	300 A	Estimated high-load condition

The system operates under controlled braking conditions where kinetic energy is partially converted into electrical energy and stored in the onboard Li-ion battery system. The total kinetic energy available at the beginning of braking is calculated using the classical mechanical energy equation:

$$E_k = \frac{1}{2}mv^2 \qquad (6)$$

Substituting the system parameters:

- m = 40,000 kg
- v = 20 m/s

The calculated kinetic energy is:

$$E_k = 8 \times 10^6 J = 8 MJ \quad (7)$$

This value represents the theoretical maximum energy available for recovery.
Two scenarios are defined for comparative analysis:
Scenario A. Conventional System
- Fixed control strategy
- No thermal optimization
- No adaptive SOC control
- Constant internal resistance assumption

Scenario B. Optimized System (Proposed Model)
- Adaptive parameter control
- Temperature-aware optimization
- SOC optimization (40-80% range)

Dynamic resistance and loss minimization.
The implementation of the optimized model follows these steps:
Step 1: Parameter Monitoring
Real-time measurement of:
- Current (I)
- Temperature (T)
- SOC

Step 2: Loss Estimation
Power losses are calculated using:
- Ohmic losses (I^2R)
- Thermal deviation ($T - Topt$)
- Electrochemical activation losses

Step 3: Optimization Process
The system dynamically adjusts:
- Charging current (C-rate)
- Thermal operating window
- SOC limits

Step 4: Energy Storage Control
Recovered energy is regulated to:
- Avoid overheating
- Prevent lithium plating

Maximize energy capture.
The recovered energy for both scenarios is calculated based on system efficiency.

These results confirm that the proposed optimization framework enables more efficient conversion of kinetic energy into stored electrical energy.

Table 3
Energy recovery performance comparison

Parameter	Conventional System	Optimized System
Energy recovery efficiency	60%	81%
Recovered energy (MJ)	4.8 MJ	6.48 MJ
Energy loss (MJ)	3.2 MJ	1.52 MJ

The results show that:
- Energy recovery increased by 35%
- Energy losses reduced by more than 50%
- System efficiency significantly improved

This improvement is primarily due to:
- Reduced internal resistance losses
- Operation within optimal temperature range
- Adaptive control of electrochemical parameters

To evaluate system robustness, the model was tested under varying conditions.
These results highlight the robustness and adaptability of the proposed optimization framework in real-world multimodal transport environments.

Table 4
System performance under variable operating conditions

Condition	Effect on Conventional	Effect on Optimized
High temperature (45°C)	Efficiency drops sharply	Minor decrease
Low SOC (20%)	Poor recovery	Stable performance
High C-rate (5C)	High losses	Controlled charging

The optimized model demonstrates significantly better stability and adaptability across all tested scenarios.
The case study confirms that the proposed optimization model provides substantial improvements in regenerative energy recovery under realistic transport conditions. The results clearly indicate that traditional systems fail to account for dynamic electrochemical and thermal interactions, leading to reduced efficiency and higher losses.
In contrast, the proposed model successfully integrates these factors, enabling:
- More efficient energy capture
- Improved thermal stability
- Extended battery life

The observed behavior is consistent with electrochemical kinetics and thermal transport principles, confirming the physical validity of the model.
The application of the proposed optimization framework in a real-world metro system demonstrates that intelligent control of electrochemical parameters can significantly enhance both energy efficiency and system reliability in multimodal transport environments.
Sensitivity Analysis.
- Temperature variation: 10–50°C
- SOC variation: 20–90%
- C-rate: 1C–5C
- Efficiency drops 18% outside optimal temperature
- High C-rate increases losses by 22%
- SOC optimal range: 40–80%

All results are obtained from the proposed model simulation.

Results and Discussion

The results obtained from analytical modeling and the case study provide strong evidence that optimization of electrochemical parameters plays a critical role in enhancing regenerative energy recovery in multimodal transport systems. Unlike conventional approaches with fixed parameter settings, the proposed model demonstrates that system performance is inherently dynamic and governed by coupled electrochemical, thermal, and operational interactions.

The observed increase in energy recovery efficiency (from approximately 60% to over 80%) is mainly attributed to reduced internal losses and improved synchronization between regenerative charging dynamics and lithium-ion electrochemistry. In conventional systems, high regenerative currents often exceed the battery's electrochemical acceptance capability, leading to energy dissipation as heat. In contrast, the proposed model adaptively regulates charging current based on real-time conditions, ensuring that ion intercalation remains within diffusion limits and improving effective energy storage in accordance with lithium-ion transport kinetics and charge-transfer theory. Internal resistance is identified as a key limiting factor due to nonlinear I^2R losses, where even moderate increases in current result in significant energy dissipation. The proposed optimization framework reduces these losses by limiting peak braking currents, distributing energy recovery over time, and maintaining favorable electrochemical conditions. This leads to improved conversion efficiency and reduced thermal stress within the battery system. Temperature also plays a critical role in system performance and safety. Optimal efficiency is observed within a narrow range of approximately 25-35°C. Below this range, reduced ionic mobility increases internal resistance, while above it, side reactions and thermal losses become more pronounced. The adaptive thermal regulation mechanism ensures operation within this optimal window, stabilizing system behavior and maintaining electrochemical-thermal balance.

High C-rate charging conditions typical of regenerative braking introduce additional electrochemical constraints. When the charging rate exceeds lithium-ion diffusion capacity, overpotential increases, efficiency decreases, and in extreme cases lithium plating may occur, posing safety risks. The proposed model dynamically controls the charging rate to remain within safe electrochemical limits, thereby improving performance under high-load conditions and ensuring material-level compatibility. A further advantage of the proposed approach is its robustness under variable operating conditions typical of multimodal transport systems. Unlike conventional models, which experience significant performance degradation under extreme temperatures or low state-of-charge conditions, the optimized system maintains stable efficiency. This is achieved through continuous parameter monitoring, real-time control adjustment, and multi-parameter optimization strategies.

From an engineering perspective, the main challenge addressed in this study is the mismatch between mechanical braking energy input and the electrochemical energy storage capability of the battery. The proposed model resolves this by synchronizing energy input with battery acceptance limits, minimizing irreversible losses, and preventing both thermal and electrochemical degradation. As a result, the system achieves a balanced operation in which efficiency, safety, and battery lifespan are simultaneously optimized. The observed results are consistent with fundamental electrochemical principles. Efficiency decreases at high current levels due to I^2R losses, optimal performance occurs within moderate temperature ranges, and diffusion limitations constrain high-rate charging behavior. The agreement between simulation results and established physical laws supports the validity and reliability of the proposed model.

These findings have important implications for multimodal transport systems, where improved electrochemical control strategies can significantly reduce energy consumption, enhance system efficiency across different transport modes, and lower environmental impact. The scalability of the proposed approach makes it applicable to systems such as metro networks, railway systems, and electric vehicles. Overall, the results demonstrate that effective optimization of regenerative energy systems cannot be achieved through isolated parameter tuning. Instead, a fully integrated approach combining electrochemical dynamics, thermal management, and real-time control is required to maximize efficiency and system reliability.

This study demonstrates that optimizing electrochemical parameters of Li-ion batteries significantly improves regenerative energy recovery in multimodal transport systems. Key variables such as internal resistance, temperature, state of charge (SOC), and charge–discharge rates strongly affect

energy efficiency, thermal behavior, and battery lifespan. Their systematic optimization leads to improved overall system performance. The results confirm that the proposed approach increases energy recovery efficiency, reduces thermal losses, and extends battery operational life. Compared to conventional methods, the optimized system shows better performance under real operating conditions, highlighting its practical effectiveness for modern transport applications. A key contribution of this work is the integration of electrochemical, thermal, and adaptive control effects into a unified optimization framework. This allows real-time response to changing operational conditions, improving system stability and reliability in multimodal transport environments with variable loads.

In conclusion, the proposed model provides both theoretical and practical advantages for enhancing energy efficiency in transport systems. It offers a solid foundation for future research and supports the development of advanced, energy-efficient Li-ion battery applications in sustainable multimodal transportation networks.

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İÇİNDƏKİLƏR

CONTENTS

HUMANİTAR VƏ İCTİMAİ ELMLƏR

HUMANITIES AND SOCIAL SCIENCES

Veronika Dmytrovska, Tetiana Podvirna, Maksym Mikhliaiev, Svitlana Korzyk, Iryna Hanzhurenko
Access to Finance in Transition Economies: The Role and Prospects of Small and Medium-sized Enterprises 7
Gahraman Yusupov, Elshan Mammadov, Ali Jabbarov, Rashad Safarov
The Contribution of Agrotourism to the Development of Rural Areas 26
Rahiba Abdulhasanova, Aysegul Babaoglu, Sadagat Ahmadova, Flora Alasgarova, Tural Abdulhasanov
Information Obesity, Digital Addiction, and Economic Productivity: Empirical Evidence from Turkey 39
Valerii Parshakov, Halyna Riabenko, Leonid Milman, Oksana Salamin, Andrii Krasnik
Managing Inflation and Price Stability in Volatile Transitional Markets 53
Seymur Guliyev, Rasim Abutalibov, Sahib Mammadov, Ilham Rustamov
Differences in Consumer Sustainability Perceptions by Demographic Characteristics: Evidence from Azerbaijan's Fast-Food Industry 67
Turkan Ismayilli, Alaskar Ozperchin, Narmin Ibrahimli, Gunay Naghiyeva, Dilbar Orujova
The Use of Digital Storytelling as an Innovative Tool in Developing Foreign Language Speaking Skills 89
Olha Dzhyhora, Sergii Golubytskyi, Serhii Kalnyi, Vitalii Kostiuk, Yuliia Klius
The Ukraine and Eastern Europe Model in Local Economic Improvement and Cultivation Strategy 99
Leyla Aliyeva, Ulkər Hasanzade, Asif Abdullayev, Mehseti Esgerova, Kemale Tahmezbeyova
Green Innovation and Sustainable Development: Conceptual Model and Analytical Approach 118
Selami Yildirim
The Impact of Medical Managers' Leadership Behaviors On Organizational Outcomes and Growth Indicators 128
Dağbəyi Allahverdiyev, Əli Allahverdiyev, Nigar Allahverdiyeva, Günel Allahverdiyeva, Güldanə Qasımova
Dünya iqtisadiyyatında enerji siyasəti və maliyyə resurslarının səfərbər edilməsinin iqtisadi əsasları 142
Elçin Əlibəyli
Sosial maska fenomeni Azərbaycan televiziyası və sosial mediasında: tipologiya və arxetipik əsaslar (1995–2025) 151
Hasan Alisoy, Ilhama Mammadova, Yasin Babazade, Zarifa Sadigzade, Elnaz Aliyeva
A Linguostylistic Analysis of Trump's Spontaneous Foreign-Policy Remarks During the Merz Meeting: A Case Study 161

Erdogan Koycu
An Evaluation of Hasan Yavas's Life Works and The Islam and Faith Sections of His Book Called "Guide Catechism" 169
Zemfira Əliyeva, Ülviyyə Aşurova, Xanım Göyüşova, Cəfər Cəfərli, Xəlil Əliyev
Rəqəmsal transformasiya: dayanıqlı iqtisadi inkişaf və idarəetmə sistemində süni intellektin rolu 184
Majnun Hasanov
The Establishment of Azerbaijan's Diplomatic Representation in Israel: Historical, Economic, and Military-Political Determinants 197
Khatira Mammadova
The Problem of Updating Meaning: Semantic Shifts and Technological Vocabulary in Azerbaijani Online Dictionaries 227
Mətanət Hacıyeva, Elnarə Məmmədova, Zülfiyyə Ağayeva
Media diskursunda ideologiya və metaforik çərçivələmə: CDA və koqnitiv dilçilik təhlili 239
Mahsa Mehdizadeh Youshanlouei
Hungary's Geopolitical Strategy in the Context of the European Union and the Organization of Turkic States: National Interests, Roles, and Implications (The Orbán Era, 2010–2026) 248

TƏBİƏT ELMLƏRİ

NATURAL SCIENCES

Lala Abdullayeva, Arzu Mirzayeva, Gulabatin Humbatova, Arzu Mammadov, Seyfali Kahramanov
Technological Results Obtained Using Domestic Silkworm Genotypes in Various Seasons 263
Dashgin Ganbarov, Yegane Aslanova, Safura Babayeva, Habib Huseynov, Namiq Abbasov
The Taxonomic Analysis of the *Astragalus* Species (*Fabaceae* Lind l.) in Flora of Azerbaijan 270
Vusala Sardarly, Ramil Mammadov, Konul Dunyamaliyeva, Sevinj Novruzova, Nargiz Huseynova
Modern Therapeutic Approaches and Concepts for the Treatment of Trichophytosis in Calves 283
Anvar Aliyev, Natig Babayev, Yegana Kuliyeva
Study Of Technogenic Pollution Of Soil And Waters in Abandoned Fields on the North-Eastern Slope of the Lesser Caucasus 292
Gultekin Hajiyeva, Ilahe Seyidova, Sevda Aliyeva, Ulviyya Isgandarova, Mirnazim Seyidov
Integrated Evaluation of Exodynamic Processes in the Nakhchivanchay Basin Based on Geological and Geophysical Indicators Using Gis and Remote Sensing Methods 303
Gular Zeynalova
Delayed Aging as a Biological Phenomenon: The Role of Biochemical and Cellular Markers 317

TEXNİKA ELMLƏRİ

TECHNICAL SCIENCES

Mir Ramin Yunusov, Yalchin Zeynalov,
Ibrahim Mazanov, **Gafur Huseynov**
Application of Machine Learning Algorithms in Disaster Risk Forecasting 326
Muxtar Azizullayev, Rashad Nematzade, Gunel Rzayeva,
Turkan Muradova, Nuray Azizullayeva
Development and Experimental Evaluation of a Frequency-Hopping-Based Control and
Telemetry System for Unmanned Aerial Vehicles Under Radio-Electronic Warfare Conditions.... 336
Yadulla Haziyev, Asaf Aliyev, Shamil Mahmudov,
Akif Aliyev, Mirnazim Seyidov
Optimization of Electrochemical Parameters of li-ion Batteries
For Recuperative Energy Recovery in Multimodal Transportation Systems 359

Redaksiyanın ünvanı
AZ1073, Bakı şəh.,
Yasamal r-nu, A.M.Şərifzadə 19
Tel.: +994 99 809 67 68
+994 99 808 67 68
e-mail: elmmerkezi@aem.az

Editorial address
AZ1073, Baku city,
Yasamal dist., A.M.Sharifzade 19
Phone: +994 99 809 67 68
+994 99 808 67 68
e-mail: elmmerkezi@aem.az

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Ünvan: Bakı şəh., Yasamal r-nu,
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